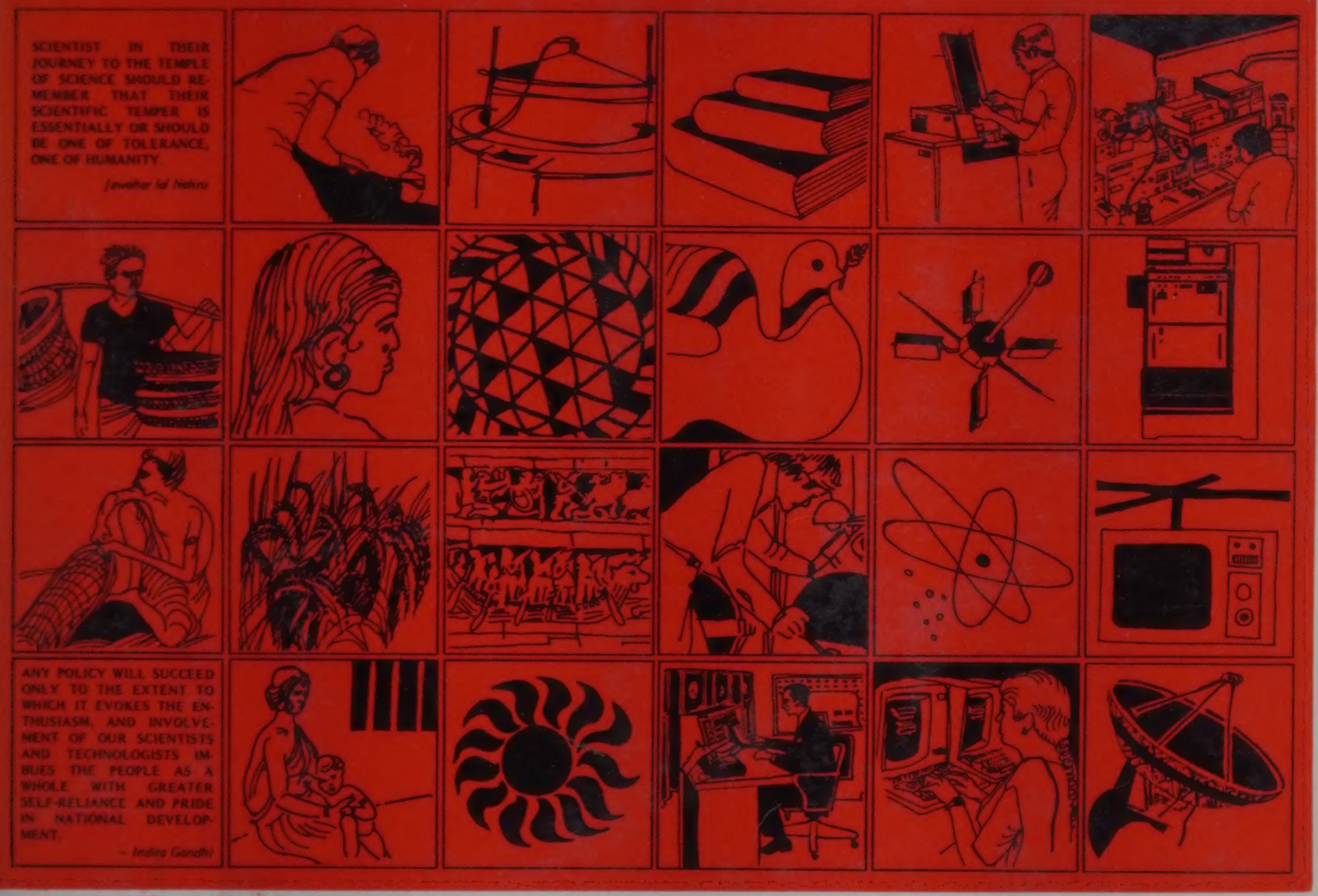
SCIENTIST IN THEIR JOURNEY TO THE TEMPLE OF SCIENCE SHOULD REMEMBER THAT THEIR SCIENTIFIC TEMPER IS ESSENTIALLY OR SHOULD BE ONE OF TOLERANCE, ONE OF HUMANITY.
Jawahar lal Nehru
ANY POLICY WILL SUCCEED ONLY TO THE EXTENT TO WHICH IT EVOKES THE ENTHUSIASM, AND INVOLVEMENT OF OUR SCIENTISTS AND TECHNOLOGISTS IMBUES THE PEOPLE AS A WHOLE WITH GREATER SELF-RELIANCE AND PRIDE IN NATIONAL DEVELOPMENT.
– Indira Gandhi

SCIENCE AND TECHNOLOGY IN INDIA

A. RAHMAN

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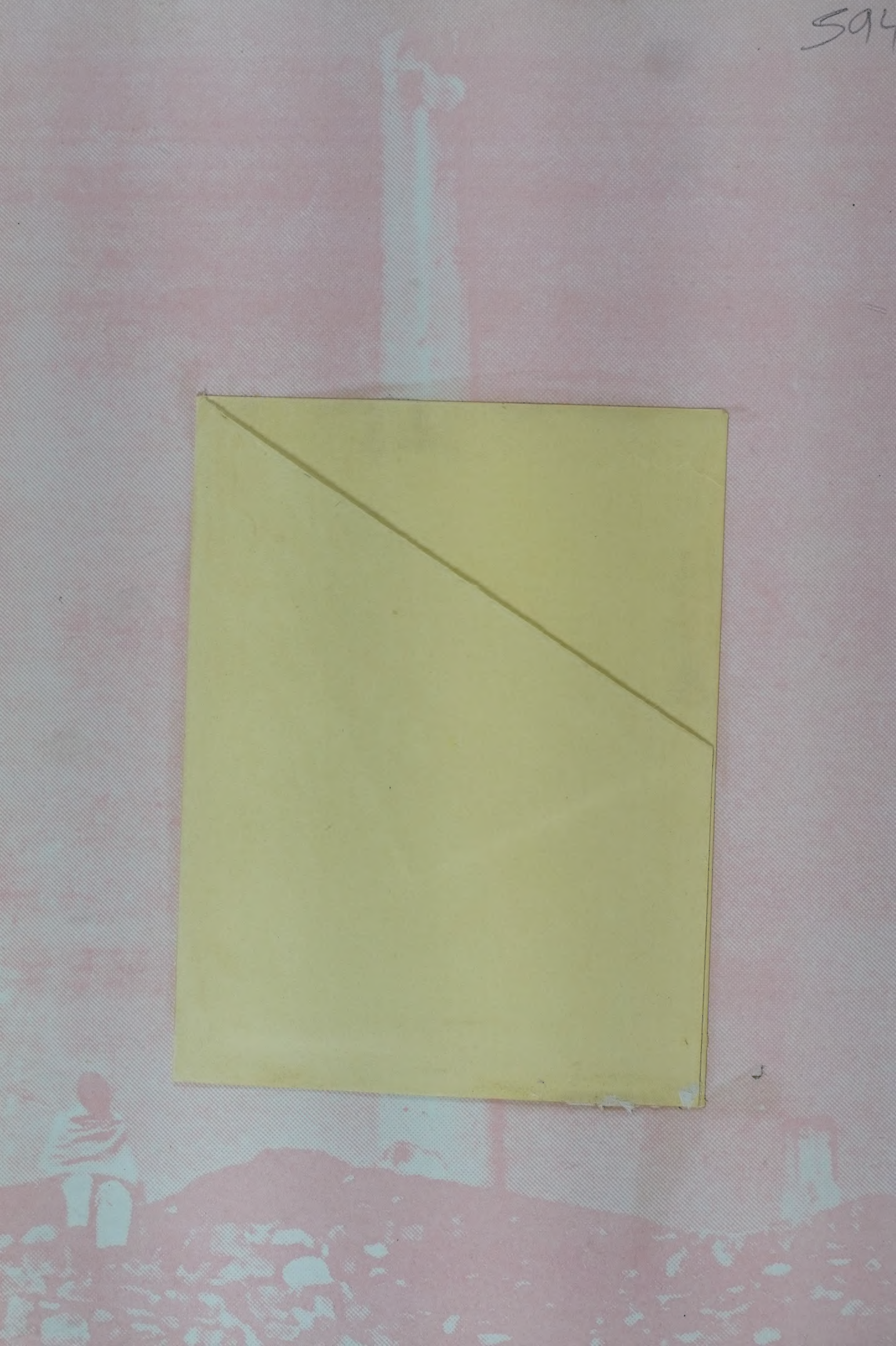

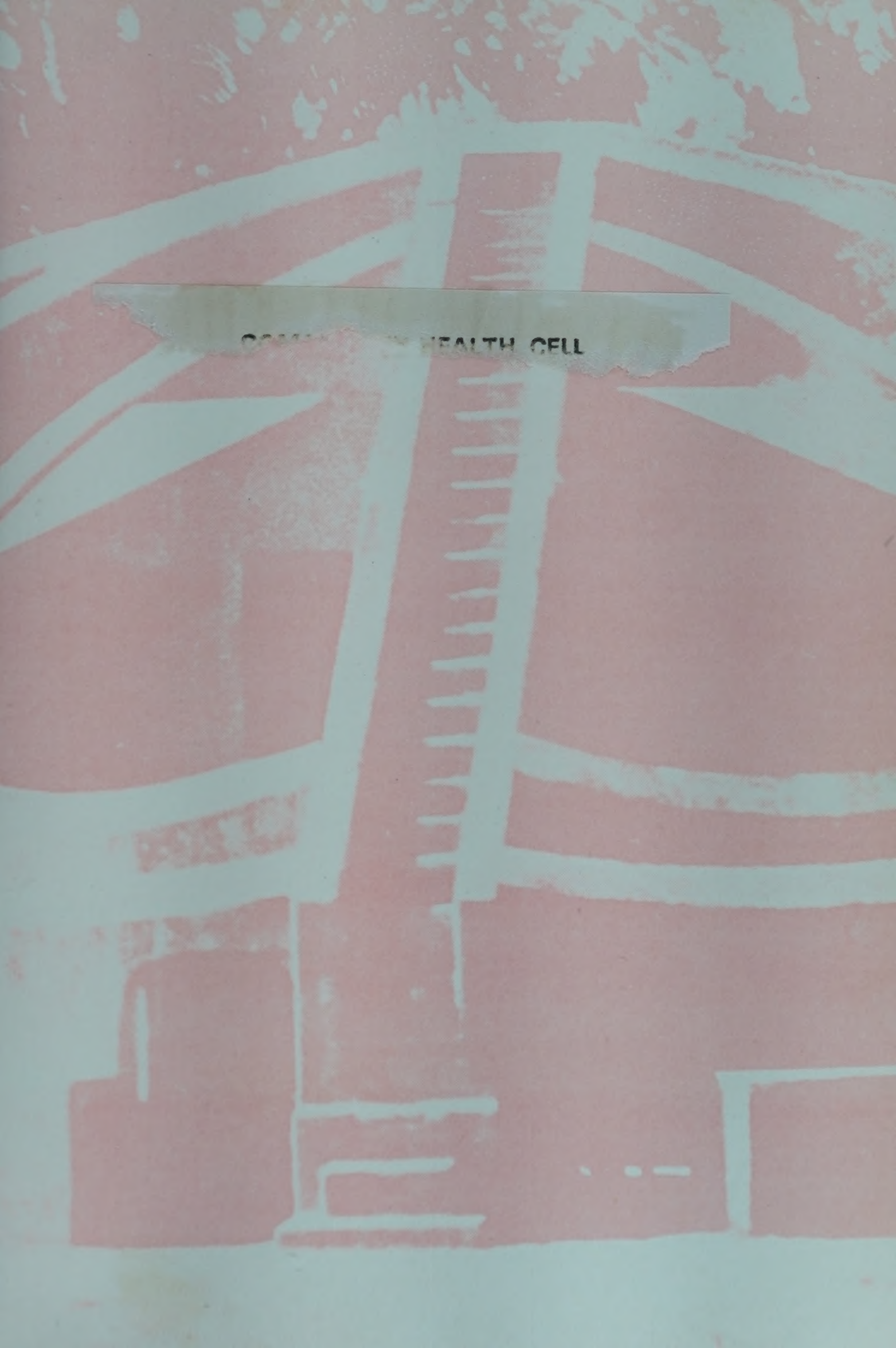
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SCIENCE AND TECHNOLOGY IN INDIA

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FEBRUARY 1984

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An anonymous reviewer, reviewing "The Fauna of British Birds", Volume II, by E.C. Stuart Baker, in Journal of Bombay Natural History Society, Volume 30, in 1925, on page 21, says the following:

"There is food, however, for reflection in the fact that we can trace no single piece of information in the two volumes which can be attributed to the work of an Indian naturalist; with the elimination of the European element in India we are about to witness the stoppage of all scientific progress in the fertile fields of the Orient, and is this work to be the Swan-Song of Indian Ornithology? It is a dismal thought."

How one wishes this anonymous reviewer was alive today to witness the renaissance of Indian science and technology since Independence!

FOREWORD

There is enough evidence available to show that in the ancient and medieval period, India was quite advanced in Science and Technology. However, the quest for knowledge and new information slowly disappeared because of the attitude towards life and because of the historical reasons. It resulted in making India weak, socially, economically and politically. Those who took advantage of this state of affairs worked to encourage that condition and continued to dominate this subcontinent and weaken its will for novelty and for unravelling the mysteries of nature.

With a strong urge to become independent, a desire to develop economically and socially also developed throughout the country. It was clearly realised that, to overcome problems arising out of poverty and destitution, one way was to develop the modern methods of production and to advance in the field of science and technology. Pandit Jawaharlal Nehru is, in fact, the architect of modern India. He inspired people to embark upon the quest for new knowledge and information, to develop scientific temper and the scientific attitude towards life.

Thanks to the inspiration and full support from him, the Scientific Policy Resolution was passed in 1958. With the cooperation and assistance of the scientists, its implementation led to the creation of the necessary infrastructure and manpower for the development of science and technology. Scientists of great reputation were asked to pool their capabilities, funds were provided, policies were formulated and departments were established to see that science and technology in India progressed in different walks of life and helped to alleviate the poverty of the people.

What has been achieved in this field has helped the country, solve many of its problems. However, unless the people know of developments in various fields and take advantage of the various discoveries and inventions, the efforts would not be useful. It is for this purpose that the book, Science & Technology in India has been brought out by the National Institute of

Science Technology and Development Studies. The information on science and technology development required for this purpose is scattered over a large number of Government departments, research laboratories, academic institutions and policy documents. This book has tried to bring all such important information at one place. The book also gives the infrastructure for research and development which the country has assiduously developed and also discusses the role of scientific community for creating the necessary scientific outlook and disseminating the scientific knowledge on a large scale to involve the people in the public debate on science. The book has been written in a language which is simple, direct and understandable by the layman and appreciable by experts. I hope this book would be useful to all the people in and outside the country, who want to have a glimpse of the scientific development in India.

9th February 1984

Shivraj V. Patil
Union Minister of State for Science & Technology and Vice President, C.S.I.R.

PREFACE

The objective of this book is to provide under its covers, information about India's scientific and technological organisation and a brief description of its development.

To provide this it is but appropriate that an idea of the tradition of learning and scholarship of the country is linked with the present developments. Consequently, a bird's-eye view of the development of science and technology of India's contribution to the world of science and technology in the ancient period has been provided. Also given is a brief idea of the development of science and technology during the colonial period.

After the indicative historical survey a brief account of the development of educational infrastructure is provided. The account also gives an idea of the policies, structure and pattern of development.

In dealing with the pattern and organisation of R&D infrastructure an idea of the management system of each organisation and of different institutions working then is also given, including their areas of work and some significant contributions.

The development of science policy, which has guided the organisation and development of research in the country, along with planning and financing of research and the institutionalised mechanism for monitoring and review has been described in brief - the latter to give the reader an idea of the basic philosophy, its implementation and mechanism adapted to renew the developments.

Scientific and technical publications provide an index of activity; their growth has been indicated to provide an index of the contributions made. Similarly, the growth of scientific and professional societies is an index of the growth of the scientific community and its interaction within and outwith the community at large. The different type of societies, their areas of work and their growth have been briefly described. Finally, is provided a brief and indicative account of the significant contributions.

India has always stood at the cross-roads of history. She has been receiving from world science just as she has been enriching the world pool of scientific scholarship. A brief account of the international dimensions of Indian science, particularly her

collaboration and cooperation with other developing countries, has been included to provide a picture of the role of science and technology in relation with other countrie's. The nature of growth of education and research could be obtained by a glance at the statistical tables, which also provide financial inputs to the system. Some comparative data are also provided to help the reader understand India's development in the international context.

In the end, a list of R&D institutions is appended to enable the interested reader to seek detailed information, should be desire so, by direct correspondence with them. We hope that the book would serve as a useful and ready reference.

(A. RAHMAN)

January, 1984
NEW DELHI.

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INTRODUCTION

India achieved her freedom from the British rule on 15 August 1947. The first independent Government formed included also a Ministry for Science and Natural Resources. This portfolio was held, to emphasise the importance the Government attached to science and utilisation of natural resources, by the Prime Minister, Jawaharlal Nehru. That this was for the first time in the world that a ministry for the promotion of science and its utilisation for development was constituted only goes to prove independent India's recognition of the primordial role of science in development.

In 1958 the Indian Parliament passed a resolution called Scientific Policy Resolution to take further steps to promote science and to fully utilise scientific and technological potential and the capabilities of scientists for the further development of the country. After assessing the success in the promotion of science and its utilisation for national development over the decade since independence the Government stated its intention and enunciated policies for future. There is no other example in the world when the Parliament of a country had passed such a resolution!

The Scientific Policy Resolution was a statement of faith as well as a commitment to science and technology: to use S&T for peaceful purposes, for the development of the country, to meet the needs of people, to provide better facilities, amenities and opportunities for their cultural development, and to promote their creative capabilities. It also enunciated steps required to be taken so as to achieve the goals set for the country.

A policy for science and technology and its implementation followed the formation of the first National Government. The policy aimed at:

(1) Expansion of educational facilities to develop the requisite scientific and technical manpower and to create centres of excellance in the universities;

(2) Creation of research and development institutions to undertake research on problems faced by the country and provide their solution, as well as to provide the technical base for the development of industry;

(3) Increasing of the available scientific and technical knowledge and involving scientists and technologists in decision making; and

(4) Promotion of scientific temper, to get rid of the intellectual backwardness of the people, to enable them to appreciate new developments, and to adopt them to bring about a new renaissance in the life of the country.

These policies created within a short span of 33 years of independence the third largest scientific and technical manpower and helped transform the country from a supplier of raw materials to Europe to the tenth industrialised country of the world. As a result, India entered the nuclear, space, ocean and Antarctica clubs. She has now capabilities which are second to none in the world.

These developments have been both remarkable and rapid; and India could justifiably feel satisfied. However, not fully satisfied with her achievements she continues her self-critical approach to her developments. In 1976, addressing the annual session of the Indian Science Congress Association at Waltair, the Prime Minister posed a major question before the scientists: Who has been benefited from the development of science and technology in India? And she asked the scientists to consider and direct their creative energies to meeting the needs of those people who were downtrodden and had not been able to benefit from the recent developments, and for the development of rural areas. In addition, she also asked them to learn the lesson from the European developments and to avoid the mistakes committed by them with regard to environment, urbanisation and other related areas.

Incidentally, it has been the tradition of the country, since independence, that the Prime Minister of the country meets the scientists at their annual congregation-the meeting of the Indian Science Congress Association, every year in the first week of January. The New Year in India begins for the scientists and technologists by assessing the earlier developments and planning for the future. Not contented with an annual meeting, the Prime Minister also requests the scientists to look into specific problems - to assess the developments so far, to know the needs, and to take steps to meet them. This is, of course, besides the responsibilities and meetings with scientists in her official capacity as President, of the Council of Scientific and Industrial Research, as Minister of Atomic Energy, and of Space Research, not to mention other direct and indirect responsibilities.

Why is the Indian political leadership involved so much with science and technology? Why have they so much faith in science and technology? Is it something new or is it part of the Indian tradition?

For some time, some of the western scholars had projected that science and technology were a western phenomenon. According to this view, it started in Greece, and after a period, called the Dark Ages, re-emerged in Europe and since then the developments have

been without any parallel in the history of mankind. These developments, according to them, have also benefited the rest of the world. Further, they tell us that Europe is now engaged in transferring this knowledge to those countries which have developed the capabilities for absorbing it. This is contrary to historical evidence as we have it today.

A cursory study of history would make it evident that science and technology have been part of the Indian culture and basis of her civilisation throughout history. In every period, throughout her history, Indians have been contributing significantly to science as well as technology. Further, this knowledge was fully available, and indeed was disseminated to different parts of the world and different cultures. China, Indonesia in the east, West Asia, Central Asia and Europe in the west benefited considerably from what they borrowed from India. The scale of activity, during the Dark Ages, can be judged by the fact that during seven centuries from 12th - 18th, more than 10,000 books were written in India in Sanskrit, Arabic and Persian in Science and Technology. This is by no means a complete list; there are many more in these languages in addition to in other languages of India.

So what is now being done is nothing new; science and technology has been part of the Indian culture and tradition, and what is being done today is only renewing the tradition which was disrupted by the colonial rule.

UNITY IN DIVERSITY

India is a vast country, almost a sub-continent. Its boundaries have a wide range of geophysical features -- ranging from high snow mountains covered, the Himalayas, to the Rajasthan desert, the Gangetic Plain, Deccan Plateau and to the lush green tropical areas of the South. Just as the geographical area is varied so are the people. People with very different physical features, dresses and habits live at different levels of development with a very rich and varied cultural tradition, going back deep into history. The diversity can be noticed as one travels from the tribal people of North East, Central India, West and South India, to the highly evolved agriculturists and farmers of both plains and hill areas, cultivating different crops under different climatic conditions, to highly urbanised and industrialised population of major cities.

In this panorama India also represents a wide spectrum of development, from highly developed artisans, producing a wide range of artistic products from grass, forest products, textiles and metal goods to those who are responsible for highly sophisticated science and technology based industrial products.

India has an area of 3.29 million sq. kilometres. It is the second most populous country of the world. It is divided into 22 States some of which are larger than some of the European countries. Its people speak a number of languages; besides English fourteen languages are recognised by the Constitution. The number of languages and dialects is indeed staggering. Some of the languages and dialects till recently had no script. The States were formed on linguistic basis. English, Sindhi and Urdu, besides Hindi which is the language of the people of five States and is the official language, are not confined to one State only.

The development of the country, since Independence, on the basis of broad indicators can be judged from the data provided in Table-

GROWTH PERFORMANCE IN THE PLANS

(Percentage)

Sl.No	Items	1st Plan 51-52 to 55-56	2nd Plan 56-57 to 60-61	3rd Plan 61-62 to 65-66	Annual Plan 66-67 to 68-69	4th Plan 69-70 to 73-74	5th Plan* 74-75 to 78-79	1950-51 to 1978-79
	Annual Growth Rate							
1.	National Income	3.6	4.0	2.2	4.0	3.3	5.4**	3.5
2.	Agricultural Production	4.1	4.0 (-)	1.4	6.2	2.9	4.2	2.7
3.	Industrial Production	7.3	6.6	9.0	2.0	4.7	5.9	6.1
4.	Per Capita Consumption	1.7	1.8	0.1	2.0	0.4	2.3	1.1
5.	Gross Fixed Investment	3.0	5.8	8.7	1.5	3.1	6.6	5.5

NOTE: Col.8 gives the trend rate calculated from a semilog regression. All other columns give compound growth rates between the base year before the Plan and the year of the Plan.

* For the time period originally envisaged for the Fifth Plan.

** This is the growth rate for net national product(national income). The growth rate of gross domestic product over this period was 5.2 per cent.

HISTORICAL PERSPECTIVE

ANCIENT INDIA

Three main centres of civilisation -- Egypt, West Asia and India - may be noticed when man emerges from the mists of antiquity to the stage of history. The Indus Valley civilisation, as it has come to be known, even though the script has yet not been deciphered, presents a picture of an advanced culture.

Archaeological evidence has proved beyond doubt that the first industrial or more appropriately the technical revolution took place in history round 4,000 B.C. and by roughly 3,000 B.C. it was completed. The main technical inventions of this period, which spread probably over a thousand years or even more of human history, have been the use and control of fire, control of flooding and irrigation techniques of agriculture, domestication and consequent harnessing of animals, smelting and use of metals, and invention of plough and wheel -- potters' wheel, wheeled carts, probably the spinning wheel as well.

At this stage of history, India was a civilised country, well advanced in technique and social organisation. This is evident from the archaecological excavations carried out in different parts of India. The cities of this period which have been excavated appear as thriving centres of commerce. Their buildings are of a utilitarian type, and so also the pottery. Most of the architecture is of burnt bricks. The art of town planning and architecture seems to have been well advanced. The cities also indicate rigorous supervision of the building activities and enforcement of sanitation rules of the city. The disregard of the laws and regulation becomes apparent later when political authority shows signs of weakness.

The geometrical planning of the city and the considerations of health and hygiene are evident from the well-ventilated streets and the well-developed system of drainage, to which special care seems to have been given from the technical point also. It reveals both scientific understanding and a technological capability to use appropriate knowledge for the betterment of every-day life. These developments, we may notice, would not have been possible without a fairly advanced knowledge of building materials, engineering, construction technology and of geometry. The size of bricks used shows an element of standardisation and knowledge of firing technology. The sanitary practices adopted indicate a high knowledge of medicine and preventive measures.

Iron Piller in Qutab Minar

The construction of ports such as that of Lothal (c.B.C. 2000) gives us some idea of the size of boats, problem of docking, construction of platforms and the degree of sea trade which was then being carried out.

The smelting of copper was known and most of the equipment was made of copper, of which there seems to have been no scarcity. The discovery of a considerable amount of copper ore in a brick-lined pit of the city indicates that smelting was carried out within the city. No furnaces have, however, been discovered. The knowledge of alloys existed as a practical art as is evident from bronze materials made. The proportion of the tin, however, does not appear to be fixed; it was usually high, sometimes as much as 26 per cent and unsuitable to impart maximum strength, rendering the bronze brittle. Lead was also known and was used in making utensils, besides objects such as the figures of animals.

The art of pottery-making was well developed. Wares were painted in polychrome or with paint made from manganiferous haematite. The artistic designs on pottery and seals suggest a familiarity with many land and aquatic animals, birds and trees. Various animals drawn are elephants, rhinoceros, lion, bison, and many domestic animals. In the absence of direct evidence, the degree of knowledge which these people possessed about these animals cannot be determined.

The picture of India which emerges roughly five to three thousand years ago, as would be evident from this, rather cursory and indicative picture, is one of a highly developed civilisation with a high level of attainment in science and technology. In fact, the enforcement of laws regulating the construction of houses or sanitary drain, indicates that the then available knowledge was used for organising social life and individual behaviour. When we come into historical period, where written records are available, we may notice a continuity of tradition in the field of science as well as technology. The achievement during the period appears, as significant as in the earlier, i.e. what could be termed as the archeaological, period whose records have not yet been deciphered.

We do not know when, how and where iron was introduced first. Most likely Indians were smelting iron much before 600 B.C. and were using it with great efficiency in weapons of war and later in agricultural and other crafts. The extent of understanding of the processes involved, proficiency attained and the development of engineering could easily be imagined from the construction of the Iron Pillar, at Delhi, which is more than 6 tons in weight and is made of pure, rustless, malleable steel. This is not a unique construction, since there is record of the same period of iron beams which were used in the construction of the temple at Konarak (Orissa).

The oldest mathematical works were Sulva-Sutras, which essentially deal with geometry -- dealing with the construction of

altars and sacrificial places. They were making a systematic use of right-angled triangles, whose sides could be expressed in whole numbers (Pythagorean triangle).

The well-known mathematicians, whose names have come down to us, belong to 5th century onwards. They were Aryabhata (A.D. 499), Varahamira (A.D. 505), Brahmagupta (7th century), Mahavira (9th century) and Bhaskara (12th century). Aryabhata deals with square roots, cube roots, areas of triangle, volume of pyramid, area of circle and a number of such other entities. In Mahavira we see the first developments of algebra, which later was developed by Bhaskara. Brahmagupta gives formulae for working out the area and diagonals of any cyclic quadrilateral, rules for the use of zero, and roots of quadratic equations. He knew the use of negative numbers. Bhaskara extended the development of algebra and composed the compendium Bijaganita.

Astronomical knowledge is recorded in the Jyotish Vedanga and the Pancha* Siddhantas. They were Paitamaha, Vasistha, Paulisa, Romaka+ and the Surya-Siddhanta. Varahamira's text (A.D. 505) gives some of idea of the older texts all of which are lost, with the exception of the last mentioned. Surya-Siddhanta, had a major influence on Indian astronomical tradition and all the later contributors -- Aryabhata (A.D. 499), Varabhamira (A.D. 505), Brahmagupta (7th century) and Bhaskara (12th century) -- and other scientific works owe much, if not all, to it.

The Indian medical knowledge begins with Atharva-Veda. Two most outstanding physicians and surgeons of this period were Charaka and Susruta. Our present knowledge of Charaka based on Drdbhala (9th century) and the present Charaka Samhita dates back to 11th century with the commentary of Chakrapanidata, even though evidence suggests that Charaka and Susruta Samhitas were standard texts by A.D. fourth century. Charaka was basically a physician while Susruta was a surgeon. Their works were based on careful empirical observations and possibly on dissection of the human body. The works of both Charaka and Susruta as well as the Sidhantas were translated into Arabic and had much influence on the scientific tradition in West Asia.

This brief, indicative survey brings to surface the development of observational sciences as well as abstract thought. In addition, there appears also considerable development in technology. This period also shows the methodology developed for acquiring knowledge and the strict rules for the verification of the knowledge so acquired. Bhaskara mentions the following steps:

Sutram - Rule
Udharana - Example

*Pancha means five. +Romaka means Roman (may be even Greek)

Sthapanam - Statement
Karanam - Solution
Pratyayam - Verification

These developments gave to Indian knowledge its distinctive character.

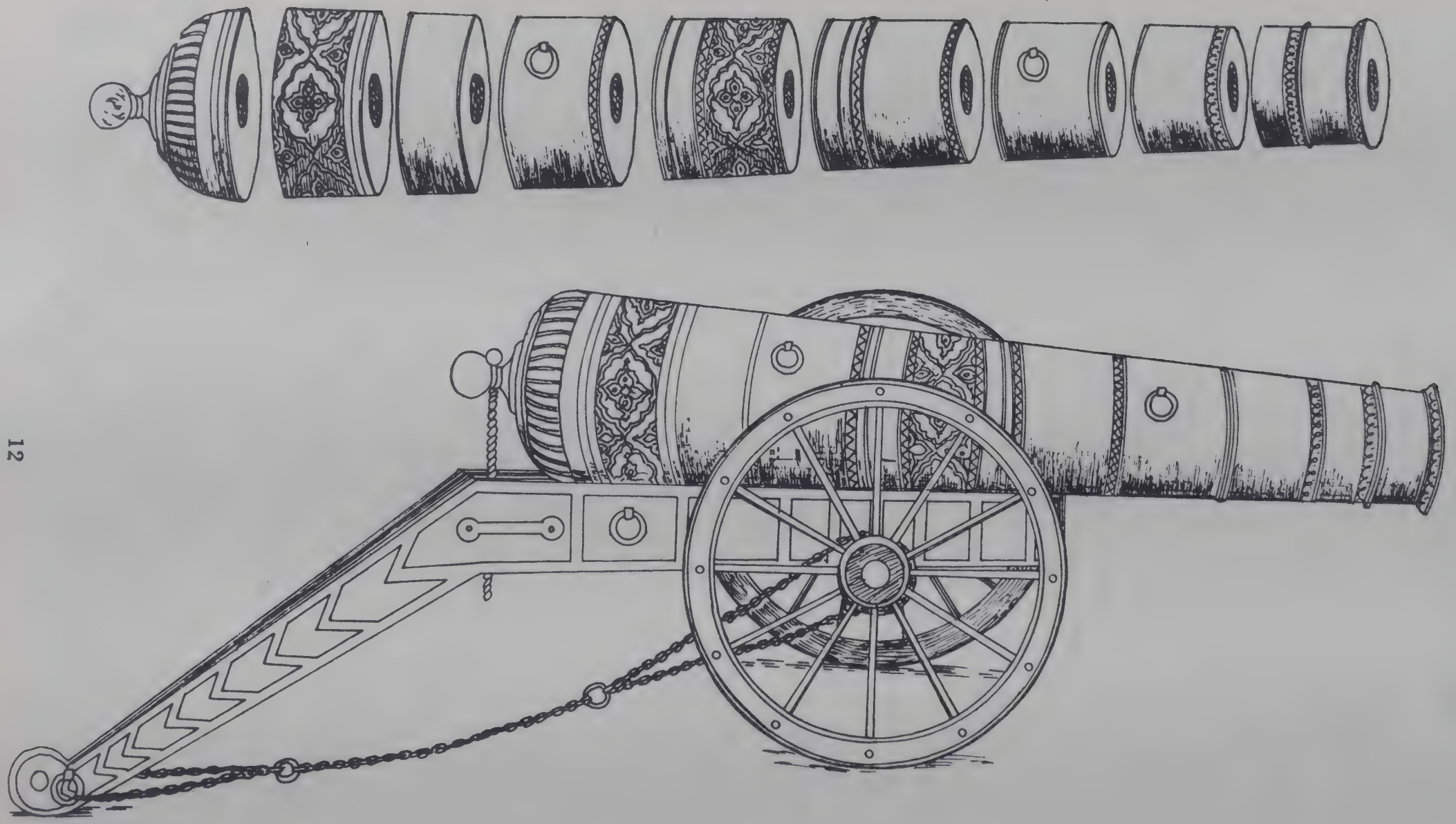
MEDIEVAL INDIA

India has always been at the cross-roads of history and has been a giver as well as a recipient of many cultural influences. It also has shown the capacity to imbibe and absorb from other cultures. In order to fully understand the contribution of the Indian religion, culture, philosophy, science and technology a study of the historical developments of Asia is necessary. Besides Vedic philosophy and culture, which spread to South-East Asia, Buddhism spread to China, and other South-East Asian countries to Central Asia and also West Asia. Along with religion and philosophy, science and technology were also disseminated.

We have extensive records of translation of Indian books into Chinese as well as Arabic and other languages. When Baghdad became a centre of Arabic learning a large number of books from Sanskrit were translated into Arabic. These were on medicine, mathematics, technology and philosophy and deeply influenced Islamic learning and thought. When later people from Arabia, Persia and Central Asia came to India and settled here, they brought back with them advanced science and technology and again reacted with Indian tradition and made notable contributions. The result of this interaction could be found in the rich treasure of manuscripts on science and technology, now spread over all the libraries of the world. In addition to specific texts on science and technology there are chronicles, memoirs and diaries and records of the emperors which give an excellent account of science and technology. Among these are such books as Sirat-Feroze Shahi (Biography of Emperor Feroze Shah, 14th century), Tuzuki Babari (Memoirs of Emperor Babar, 16th century), Aine Akbari (Records of Emperor Akbar, 16th century), Tuzuk-Jehangiri (Records of Emperor Jehangir early 17th century); and the 18th century astronomical and other works of Raja Sewai Jai Singh II of Jaipur. The detailed descriptions, illustrations, drawings of machines, paintings of birds and other animals are not only truthful but are also extremely beautiful with no parallel in history.

ASTRONOMY

The main purposes of astronomy were working out a calendar; fixing the dates of seasons, religious and other festivals; casting horoscopes for marriages and other purposes; meeting administrative requirements, and for use in navigation and calculation of time. The casting of horoscopes gave the



The Portable Cannon

astronomer-cum-astrologer his social importance, and its study, a greater degree of social utility.

The main observatories were at Ujjain, Benaras (now Varanasi), Mathura, Jaipur and Delhi. The first two were the old observatories. The one at Delhi was first organised by Humayun (16th century) at Sher Mandal, though a few observational posts were also erected at the time of Firoze Tughlaq (14th century) and finally by Raja Sewai Jai Singh II of Jaipur in the reign of Muhammad Shah (18th century). There was an observatory, at Daulatabad, established by Firoze Shah Bahamani under Hakim Ali Mohsin and Saiyaad Muhammad Kazimi. Shah Jehan (17th century) had also proposed to build an observatory for Mulla Mahmud at Jaunpur, but it could not materialise for lack of funds.

The chief instrument for astronomical observation was the astrolabe. This reached its zenith in the 17th century in India; of that period about 40 astrolabes are still extant. Lahore seems to have been a major centre for the industry. Of the astrolabe makers we have an account of one family from the time of Humayun to Aurangazeb (16th century to the end of 17th century). Besides the astrolabe, the other instruments used were quadrants and armilliary spheres of various types.

Both lunar and solar calendars were in use; and based on these, a number of calendars, depending upon the language of the writer or the country of his origin, were current. As to the shape of the Earth, the general belief varied from that of a flat body to a solid sphere; its rotation though discussed was refuted, and geocentric theory was generally accepted. The phenomenon of seasons was explained on the basis of the revolution of the Sun in general, the Ptolemaic scheme being in vogue.

Most of the books written during the period were commentaries on the earlier works, mostly of Tusi, Al-Kashi and other astronomers, or translations from Sanskrit works. Of the Sanskrit works themselves, tables of Makaranda (1478) and a little later Tithyapipattra or Grahalaghava of Ganesa (1528) and Tajika* Neelakantha (1587) are worth mentioning. Three astrononomical tables were produced: Zij-i-Shah Jehani (1628-29) by Farid'd-Din Masud bin Hafiz Ibrahim Dehlavi (d.1629). In the reign of Shah Jehan, another book Parsiprakasa (1643) by Malajit was compiled. It deals mainly with conversion of dates. Zij-i-Jadid Muhammad Shahi was written, a century later, by Raja Sewai Jai Singh II of Jaipur and is by far the most outstanding book of the period.

The finest and the best chain of observatories was, however, erected by Raja Sewai Jai Singh II of Jaipur at Delhi and Jaipur. These were started in 1718 and completed in 1734. The observatories constructed at Ujjain, Mathura and Benaras no longer

*Tajika means Tadjik, perhaps referring to its Central Asian source.

exist. The chief feature of these was the masonry instruments which he had erected in preference to small metallic ones to increase the accuracy of measurements.

Jai Singh's introduction to his tables, Zij Jadid Mohammad Shahi, reveals his scientific mind. When asked to undertake the reform of the calendar he proceeded by first collecting information about the developments. He sent his emissaries to Europe, West Asia and China and invited astronomers, including Europeans to his court. He further set himself the task of reforming instruments of observation, enumerating the inadequacies of the then existing ones and constructed a number of observatories for the carrying out of observations.

Mathematics

Before the period begins two outstanding Indian mathematicians had made major contributions: Sridhara in the 11th century (b.991), who wrote Ganita Sara, and Bhaskara in 12th century, whose contributions were Lilavati, Bijaganita and Siddhanta Siromani. Ganita Sara deals with multiplication, division, square root, cubes, fractions, zero, natural numbers, partnership, mensuration and shadow reckoning. Bhaskara's Lilavati covers notation, operation with integers, fractions, commercial rules, interest, permutation and combination with algebra. Bijaganita discusses directed numbers, negative quantities (unknown quantities are designated with colours) and simple and quadratic equations. In Siddhanta Siromani, Goladhyaya deals with spheres.

Riadi (Mathematics) during the period comprised Hisab (Arithmetic), Hindsa (Geometry), Hai'at (Astronomy) and Mausiqi (Music).

The mathematicians whose knowledge was frequently used were Bahau'd-Din Amuli (16th, 17th century), Nasirud-Din al-Tusi (13th century), Arraq (11th century), and Al-Kashi (15th century). Amulis Khulasatul-Hisab was used throughout the period and seems to be the most popular. In Sanskrit the works of Narayana Pandita's Ganita Pali Kaumidi (1356) and Nayana Sakha's Ukranthya Grantha (1731) are worth mentioning.

In Arithmetic the general lines comprised positive integers, fractions, rule of three, method of trial and error, menusuration, measurement of weight and calculation of distance.

In Algebra the general development was on the lines laid down by Al-Khwarizmi, Bhaskara and Amuli. Asmatu'llah Sahranpuri (17th century) contributed to the quadratic equations. The main effort in this field has been towards evolving some useful formulae and solution of some of the problems, inherited from predecessors.

In geometry, Euclid's translations were the most commonly used and a large number of Sharh (commentaries) were written on them. Of these two in particular, Sharah-i-Uqlidus (commentary on Euclid) - one by Mir Mohammad Hashim (17th century) and the

other by Moulavi Muhammad Barkat (18th century) - were the most important ones, and make a contribution to the theory of parallel postulate.

Apart from the contributors mentioned, another illustrious family which contributed considerably to the development of mathematics, by way of translations or commentaries, was that of Ustad Ahmad al-Mi'mar Lahori, the builder of Taj Mahal, his sons 'Atau'llah Rashidi, Lutufu'llah Muhandis+, and Muhandis' two sons Imamu'd-Din Riadi* and Khairullah. Riadi is said to have written 25 books on various subjects, particularly on mathematics and astronomy.

MEDICINE

Medicine covered a range of subjects including those of dietetics and what we now call food technology. The main emphasis throughout the period remains on the diagnosis of diseases and their cures. In diagnosis, special emphasis was given to causes and symptoms (asbab-o-'alamat) by the observation of the general conditions of the patient. This was done by the feeling of the pulse and the examination of the urine. The latter techniques, though non-quantitative and non-chemical, were developed considerably; they depended on prolonged experience for correct inferences. A treatise of the 17th century Thufutu'l-Momi-min by Muhammad Momin Husaini Tunkabani, written in Persian, was widely used in India. It discusses in detail the causes of differences of opinion amongst physicians regarding drug action.

Specialised treatises written on diseases, such as fevers, organs of the body, e.g. eyes, stomach, seem to suggest detailed and specialised knowledge based on observation and acquired by long experience. The treatise on eye, Nuru'l Ayun by Zarrin Dust (1087-88) gives the constitution of the eye, its diseases which can be seen and those that cannot, and suggests prophylactic measures for preventing the diseases.

Buhwa bin Khawas Khan's Ma'danu's-Shifa' Sikandar Shahi (1512-13), written in Delhi for Sikander Shah Lodi, is based on Sanskrit sources and uses Sanskrit terms extensively.

Considerable emphasis was given to dietetics and hence a number of treatises of the period show the care and thought given to it. In this connection the preparation of food preserves (murabbas, chuttneys) and beverages (sherbats) may also be mentioned. The former were both by pickling and through preservation in sugar syrups.

In the preparation of drugs, considerable empirical knowledge was accumulated, relating to the description of medicinal plants and their properties, preparation of decoctions and extracts, and the study of their effect on human body. The mode of preparation

+Muhandis means Geometer *Riadi means Mathematics

led to the development of chemical practices such as extraction, distillation, evaporation and drying. Necessary apparatus for the purpose was developed. Oils and perfumes were a part of the medicine and details about their preparation, direction for their use, and their benefits are given in medical texts.

General regard for sanitation was part of the medical practice and various directions in this respect are given such as in Riyaz-e' Alamgiri of Mohammad Raza (1660-70-85).

Of the Sanskrit works, mention may be made of Tisata's Cikitsa Kalika (14th century), Bhavaprakasa (16th century) of Bhavamisra and Vaidyajivana of Olimbaraja (17th century). A very interesting book in this connection is Vrksayurveda (15th or 16th century) by Surapala on plant diseases.

The knowledge and practice of medicine reveals a strong and vigorous tradition, but it is a tradition. It remains an art which is acquired by the observational acumen and long practice, a practice where the experience is gained by each physician afresh. The practice of medicine was centred, like every other discipline, on distinguished physicians though a few references are made regarding the organisation of hospitals. The practice, preparation of drugs, and teaching, all centred round individuals.

CHEMISTRY

There were four elements: fire, earth, air and water, with four qualities (Khawas): hot, dry, moist and cold. There were neither any definite ideas regarding chemical combination nor any understanding of the chemical nature of substances. The alchemical practice of philosopher's stone and elixir of life brought in charlatans and adventurers. In its association with medicine, various chemical compounds were prepared for use as drugs, like those of mercury, arsenic; and extracts and decoctions from different herbs.

In industrial manufacture or processes, again a range of operations were adopted, based on empirical knowledge and practical acumen acquired through experimentation over years. The processes which were known were those of (i) dyeing including the manufacture of dyes; (ii) sugar making; (iii) paper manufacture; (iv) manufacture of common salt and other salts, such as salt peter; (v) perfumery and scented waters; and (vi) turpentine oils. Mineral acids were known and used. Making of both fireworks and weapons was well known. In their preparations some effort for quality control was made. Mention may also be made of the glazed tiles and pottery made during this period.

The technical skill combined with chemical knowledge was of a high standard, but the knowledge remained at an empirical level and codified into a set of practices which were to be followed rigorously if good results were to be achieved.

METALLURGY

Metals which were extensively used were: copper, iron, tin, gold, silver and lead, in making utensils, weapons, images and ornaments, either as such or as alloys; bronze and brass were also extensively made and used; as also iron, steel, and an alloy of lead called Bidari. The general emphasis throughout the period remained on the use of metals, and other alloys for making of ornaments or decorative objects.

Cannons and guns were made of brass, bronze, iron and steel. These were generally used in India from 1400 onwards. The mining of the metal and the casting was made in a simple manner based on local practices in different areas.

The coating of copper utensils with tin came into vogue and gained much currency; it appears to have been introduced round about A.D 1300. Abul Fazl mentions of the tinning of copper vessels for use in the royal households of Akbar. The lead alloy Bidari was used mostly for the articles of decorative character (8:2:1 copper, lead and tin). White and coloured enamels were also developed and used.

In regard to the knowledge of various metals, particular mention may be made about zinc. This was not known in Europe till very late. Abul Fazl in Ain Akbari makes a particular mention that Indians knew about it while it not known in Europe.

ARTILLERY

In several ways, artillery represented the highest achievements of industrial technology during the 16th and 17th centuries. The manufacture of cannons was a major industry. On the hand-guns were lavished all the fruits of the increasing mechanical sophistication as well as craft, beauty and aesthetics attained during that period. In the 17th century Indian guns were equipped with flint-lock. The barrel was made by getting rolls of flat iron, twisted around with one edge running over the other, welded by heating and then bored from inside, and the technique was the same as was adopted in Europe.

In the manufacture of cannon, two trends were noticed in the Mughal period. One of these was the improved method of making large cannon and was apparently similar to the one employed by Ottoman Turks during the middle of the 15th century. By the end of the 16th century, the heaviest guns in the world were being cast in India and the climax was reached with the famous Malik Maidan cast in bronze at Ahmednagar. Another aspect of the artillery was the use of ban or rocket, by the Indian armies. These rockets were very effective and were made of bamboos with iron cylinders containing combustible materials. The account of the work of

Shirazi showed high mechanical skill as can be seen from the making of screw cannon, wagon mill and gun cleaning machine.

Navigation underwent considerable changes during the 17th century. Among the instruments used in ships was the astrolabe for determining time and latitude. In addition, Indian sailors had started using a magnetic needle floating on water, as an instrument similar to the compass, as early as 13th century.

Ship and boat making was well advanced and many of the European sail ships, Portugese and British, were made in India. The great demand and manufacture of ships had led to considerable deforestation on the West coast of India.

AGRICULTURE

The capacity of agriculture to accept new crops could be gauged through the rapid and extensive cultivation of tobacco and maize during the Mughal period. One of the advanced agricultural practices prevalent during this period was dibbling, i.e. dropping of seeds into holes driven into ground by sticks used mainly for cultivation of the cotton. As far as the agricultural implements are concerned, the use of metallic Persian Water Wheel by peasants was the principal means of water-lifting. It was also a period of considerable innovation in horticultural practices. These practices were not only confined to the introduction of certain new fruits and vegetables but the major innovation was the technique of grafting and its extensive use in improving the yield and quality of fruits. During the reign of Shah Jahan the practice of grafting became widespread and as a result of its application the quality of oranges, mangoes and peeches had greatly improved. A number of new plants were introduced, brought by Portugese from Latin America, such as pine-apple and others. There is some account of these in Tuzaki Jehangiri (memoirs of Jehangir).

There is also some evidence of use of water mills both for irrigation and for grinding corn.

TEXTILE TECHNOLOGY

The textile industry underwent significant changes during the period. The spinning wheel was given its crank handle, fancy weaving techniques were in vogue, and direct block printing came into use as a cost saving device. Two important instruments for ginning and cleaning cotton were the wooden worm-worked roller (charkhi) and the bow scutch (kaman). They had come into use by the 13th and 14th centuries. Later on this charkhi, locally called belna, was driven by water power. During the Mughal period Indian spinning wheel was furnished with crank handle.

Evidence also exists to reveal that the figured silks, cottons and brocades of highest quality were woven during the 17th century. The basic methods of the multicolour pattern dyeing, the application of resins to confine colours to patterns and of mordants to fix colours were also very common during the 11th century. Wooden blocks, for putting impressions on cloth, were also popular as recorded in the Indian dictionary, Bahri-i-Ajam.

ARCHITECTURE

The medieval period all over India represents the flowering of architecture. The buildings made are both imposing as well as of extreme beauty. In achieving these aims, it appears considerable experimentation was carried out in the use of building material, design and construction techniques. Detailed accounts of those construction are available. Who has not heard of Taj Mahal, a building both imposing as well as of extreme beauty? Its builder Ustad Ahmad Al Mi'mar Lahori (literally means Master Ahmad the builder Engineer from Lahore) was a great mathematician and wrote many books including those on Geometry.

During this period we find from Bengal to Sind and from Kashmir to Kanyakumari a series of developments of using stone or bricks as building material, development of lime-plastering or stone as surfacing material, intermingling of styles and designs and development of buildings to suit various functions and purposes, from defence needs to decorative purposes, mosques, temples, forts and mausoleums. Side by side with the development of buildings we have the development of parks and gardens as part of the building complex as well as technology of providing water to buildings, construction of fountains and other contraptions to meet the needs or to add to the pleasure or aesthetics.

The hydraulics seems to have been considerably developed. It was to provide running, soft water to palaces and forts, particularly during siege and also for comfort and pleasure. Elaborate systems for these purposes were developed and great ingenuity was used in organising the supply of hot and cold water for bath, for cooling the palaces in summer and for fountains.

Efforts were also made to construct bridges over rivers. These, however, did not prove useful. The heavy piers acted as an obstruction and led to the deposition of heavy silt which the rivers carried. As a result the rivers changed their course. Technical effort was not directed to the solution of the problem since the degree of traffic was not high and rivers provided a natural barrier for purposes of defence. The development of technology, culture and aesthetics as would be evident went hand in hand as a part of life of the medieval period.

SCIENCE AND TECHNOLOGY DURING THE BRITISH RULE

Contemporary science and technology was introduced by the British, as a substitute and in opposition to the traditional system of Sanskritic and Arabo-Persian learning prevailing at that time. It was also introduced in English language, which was not the language of the country. Further, the development of education was also influenced by political considerations, expediencies, and political and economic objectives of the colonial power.

The developments during the British period reveal that these were essentially meant to meet the needs and requirements of the then Government. If they helped in the development of the country, it was only an unwitting spinoff. The Government established various services to cover the fields of medicine, engineering, surveys, as a part of the military organisation, in order either to increase revenues, alleviate certain conditions, or to meet the requirements of the imperial power. The purpose of undertaking trignometerical, topographical, hydrographic, geodetic and geological surveys was primarily to ensure the military, administrative and economic control over the country. In addition, there was a deliberate policy to keep the natives away from responsible positions and there were differences in emoluments between Europeans and Indians.

Indians were excluded from senior appointments under the British administration, thus preventing them from effective participation in Government scientific undertakings and in decision making. However, despite these factors, a viable infrastructure of science and technology came into existence.

EARLY DEVELOPMENTS OF EUROPEAN SCIENCE AND TECHNOLOGY IN INDIA

The public interest in India in scientific research, according to newer methods, began with the foundation of the Asiatic Society in Calcutta in January 1784, by Sir William Jones, Judge of the Supreme Court, who was also its first President. Through the effort of this Society, the Indian Museum of Calcutta was founded in 1866.

From about the middle of the 19th century, the Asiatic Society started publishing papers in physics, chemistry, geology and

medical sciences and thus played an important role in the development and advancement of sciences in India. The Society first began with translation of Sanskrit, Arabic and Persian scientific and technological and philosophical texts. These were later discontinued. The latter, perhaps, was due to the policy of undermining the scientific and technological tradition of the country and suggesting that these were part of European tradition.

An Agricultural Society of India was established in 1821, its name was changed to the Agricultural and Horticultural Society and later to Royal Agri-horticultural Society. Madras Literary Society was started in 1833. It started a journal under the title of Madras Journal of Literature and Science. The Indian Association for the Cultivation of Science founded, in 1876 by Dr. Mehandra Lal Sircar, provided laboratory facilities and became one of the foremost scientific research centres in the country. Mention may also be made of the Bombay Natural History Society, which was founded in 1883, and Indian Mathematical Society, which was started in 1907 mainly through the efforts of V. Rangaswami Iyer under the name of Analytical Club with its headquarters at Fergusson College, Poona. The Indian Mathematical Society soon changed its name to 'The Indian Mathematical Club', finally renamed the Indian Mathematical Society in 1911. The Society published a quarterly journal, the Journal of Mathematical Society. Calcutta Mathematical Society was established in 1908 with Sir Ashutosh Mukhopadhya as the first President, with the objects of fostering and encouraging the study of mathematics in all its branches, promoting the spirit of original research, and publishing a periodical.

As a result of the efforts of Prof. P.S. MacMohan of Lucknow and Prof. Simon of Madras, the Indian Science Congress Association was formed in 1914. Its first session was held in Calcutta under the chairmanship of Sir Ashutosh Mukhopadhya, the then Vice-Chancellor of the Calcutta University. The establishments of these societies played a major role in creating a scientific consciousness, in bringing scientists together and enabling them to pressurise the Government for greater support to science.

GOVERNMENT AGENCIES AND DEVELOPMENT OF SCIENCE AND TECHNOLOGY

The main scientific activities in the Government sector were largely carried out by the Medical and the Engineers Corps of the Army and Civil officers interested in science, as a spare time activity. These men, trained in European institutions and laboratories spent the best parts of their lives in India, and left a record of their work and a mark in various branches of sciences

through original contributions. They were responsible for publishing considerable literature on science and technology, building a sizeable store of the scientific apparatus, chemicals and research tools, and founding a few of the important scientific institutions in the country. Most of all they created a tradition of dedicated scientific research, which was picked by Indians who worked under them and later carried this forward.

SURVEYS AND SCIENTIFIC RESEARCH

Geologists had been employed since 1818 for survey work. The Geological Survey of India was organised in 1851 with the arrival of Thomas Oldham, the then Professor of Geology in Dublin. The beginning of geological studies may be traced in the last quarter of 18th century. Benjamin Heyne, a member of the Society of United Brothers and Superintendent of Samukotta Nurseries, carried out research in minerology and metallurgy. A series of discoveries of Siwalik fossils, and research on these, were made by H. Falconer and P.T. Cautlay, who were jointly awarded in 1837 the Wollasten Medal of Geological Society of London.

The Trignometrical Survey of the Peninsula of India was established in 1800 and was expanded as Great Trignometrical Survey of India in 1818. The Topographical and Revenue Surveys grouped together under the Surveyor General of India in 1817 and a School for Surveying established in Madras after several transformations, were consolidated with Trignometrical Survey in 1878 at the Survey of India.

With the establishment of Botanical Gardens in 1788, it became possible to carry out systematic botanical studies in India. Dr. William Roxbery was the first to start research on Indian plants in Botanical Gardens. The Botanical Survey of India was established in 1890 with Sir George King as Director. The survey started functioning in a skeleton form with only two units. One of these consisted of the Industrial Section, the Indian Museum and other Systematic Divisions, while the other comprised the Indian Botanical Garden only.

Zoological research in India dates back to the appointment of Edward Blyth as the Curator of the Museum of the Asiatic Society in 1841. His successor, John Anderson in 1866 became the first Superintendent of the Indian Museum with the zoological and archaeological collections under his direct charge. Zoological research was carried on under John Anderson, J. Wood Mason, A.W. Alcock and N. Annandale, who later started two journals: the Records and Memoirs of Indian Museum which helped considerably in the advancement of zoological research in the country. In 1916, the Zoological and Anthropological Sections of Indian Museum were converted into the Zoological Survey of India.

INDUSTRIAL RESEARCH

It may be of interest to note here that those areas of science and technology which served British industrial interests were developed early, industrial research and needs of industry were not given any attention by the British. The latter was due to the fact that they had wished to keep India as a supplier of raw material to British industries and market for British manufacturers. It was only the requirements of the First World War and the political pressure of the national movement which led to the appointment of Holland Commission in 1918 for appraising, amongst others, the status of the then existing industrial research facilities, and to make recommendations for its improvement. However, very little was done till 1935 when the Government of India established an Industrial Intelligence and Research Bureau with the object of "making a beginning and to lay the foundation on which a research organisation suitable for the needs of the country could later be constructed".

An Industrial Research Council was set up to advise on measures for the coordination and development of industrial research. A Research Branch of the Bureau was located in the Government Test House, Alipore.

It was the needs of the war again, the Second World War, which forced the then Government to establish units to serve the needs of the besieged Britain. In order to do so they had to think of organising research and this led them to establish the Board of Scientific and Industrial Research to advise the Government on research for development of Indian industries, particularly those connected with the war.

The Board of Scientific and Industrial Research emphasised the need and provided the basis for a central organisation to plan research, to bring about effective coordination of the research activities of the country, and to promote the application of research for national development. In 1942, an Industrial Research Fund was created by the Government for the purposes of fostering industrial development in the country and the Council of Scientific and Industrial Research was constituted as an autonomous body to administer the Fund. As early as 1942, the proposals for the establishment of National Physical Laboratory and a National Chemical Laboratory had been accepted, and later plans for other laboratories for food technology, building, road, leather, electro-chemicals and others were formulated. These plans were taken up after Independence and research institutes established for these areas. This was incidentally on the lines of the institutes established in U.K. under Department of Scientific and Industrial Research.

MEDICAL RESEARCH

The high incidence of diseases unknown to the west, and cost of their treatment, and their impact on army and administration necessitated research relating to diseases like Cholera, Plague, Malaria, Beri-Beri, Kala Azar, etc.

In 1892, the Bacteriological Laboratory at Agra was established with Mr. P.H. Hankin as its Head. The spreading of plague at Bombay in 1896 led to the deputation of Mr. W.M. Haffkine to work on this problem and subsequently to the appointment of a Member of Plague Commissions of Britain, India, Germany and Russia to investigate the epidemiology of the disease. In 1899, Haffkine developed a plague vaccine and established a small laboratory, called Plague Research Laboratory, Bombay. In 1926, it was renamed as Haffkine Institute, Bombay. The Pasteur Institute was established at Kasauli in 1900. Three years later, the King Institute was established at Guindy for the manufacture of Calf-lymph and for general bacteriological work. In the year 1907, another Pasteur Institute was set up at Conoor in the south. In 1910, Sir Leonard Rogers proposed the establishment of the School of Tropical Medicine in Calcutta.

Thus a chain of institutes with facilities for medical research were established and a cadre of scientific workers in this field created. The efforts of Sir Harcourt Butler, first Member of the Department of Education, Health and Lands, of the Viceroy's Executive Council and Sir Pardy Lukis, the Director General, Indian Medical Service, resulted in the establishment of an Indian Research Fund Association in 1911. The primary objectives for which the Association was established were the prosecution of and assitance to research, propagation of knowledge and experimental measures generally in connection with the causation, mode of spread and prevention of communicable diseases.

AGRICULTURE RESEARCH

A beginning of agricultural research was made with the establishment of the Agricultural Research Station and Experimental Farm (later called the Imperial Institute of Agricultural Research at Pusa, Bihar) with the help of a donation made by an American philanthropist, Mr. Henry Phipps of Chicago. Subsequently, funds were provided for the development of agricultural research and education. In many provinces, a separate Department of Agriculture was constituted. Agricultural Colleges were established at Poona, Kanpur, Nagpur, Layallpur (now in Pakistan), Coimbatore and Sabour.

In 1921, agriculture, which had so far been a central subject, was transferred to provinces. The latter were to deal with policy, its administration, coordination of agricultural research and education. A Royal Commission on Agriculture was appointed in

1926 to examine and report on conditions of agriculture and the rural economy of India with particular reference to the measures being taken for promotion of agricultural and veterinary research and education. As a result of the recommendations of this Commission, the Imperial Council of Agricultural Research was established in 1929 with the primary object of promoting, guiding and coordinating agricultural research and education in India. The Council was also to serve as a link between agricultural institutions in India and foreign countries.

Apart from the Indian Council of Agricultural Research, a number of Central Commodity Committees dealing with research in particular crops, namely cotton (1921), jute (1936), sugarcane (1944), tobacco (1945), coconut (1945), and oilseeds (1947), were also set up as semi-autonomous bodies, financed by the grants from the Government of India or by income from cess levied under specific Acts.

A Bacteriological Laboratory was established in 1889 in Pune and subsequently it was transferred to Mukteshwar in 1893. The Izatnagar branch was opened in 1913 and the name changed to Imperial Veterinary Institute. It is now known as Indian Veterinary Research Institute with headquarters at Izatnagar, Bareilly.

RESEARCH IN PRIVATE INSTITUTES

Research activities in private institutes were not very significant. A few institutes were established by scientists or public men, and bear the names of their founders. A few worth mentioning are: Indian Institute of Science, Bangalore (1911); the Bose Institute, Calcutta (1917); the Indian Academy of Science, Bangalore (1934)(the Raman Research Institute at Bangalore is a part of it); Sheila Dhar Institute of Soil Sciences, Allahabad (1936); the Tata Institute of Fundamental Research, Bombay (1945); Shri Ram Institute for Industrial Research, Delhi (1947). Some of these Institutes like the Indian Institute of Science, Bangalore established by Tatas played a notable role as a centre of research at a time when India possessed few research facilities. Their development, however, was accelerated only after Independence. These institutes are now centres of higher studies and research in their respective fields. A few of these institutes have also attained the status of the universities.

It may be worthwhile to mention briefly two features of the development of science and technology during the period under British rule. Firstly, though the policy of promotion of science and technology and their use for developing agriculture, health and industry was guided by the political consideration, a number of dedicated British scientists made notable contributions. These scientists found in India unlimited possibilities for contributing to

knowledge. They, therefore, finding these opportunities and possibilities made notable contributions to science - through surveys of plants and animals, in the field of pathology of tropical diseases in particular, in the field of engineering by way of construction of railroads, roads, canals and bridges, in the field of chemistry of natural products, in the area of cultivation of food and agriculture, as well as commercial plants.

They also established a number of scientific and professional societies and associations. Their deliberations, new standards of objectivity, respect for facts as a part of discussions created a new awareness amongst people, made them realise the importance of science and technology and the possibilities of development through their use. Further, through their example they also left a tradition of dedicated work.

Secondly, the development of science and technology in India during the British period is also an interesting example of how scientific and technological infrastructure, once created, begins to interact with situations and opportunities and helps in promoting a self-generating scientific and technological tradition. Two factors gave a major thrust to the development during the British period. Firstly, needs of war generated demands of materials and products which could not be produced without research and hence the two wars gave a major push and support to creating organisations for research and establishment of industries. Secondly, the linkage between scientific community and the political leadership of the Independence movement continuously brought pressure on the then Government for greater educational facilities in science and technology, research facilities and creation of industries. The result of these was that when India became free it had, in contrast to many other colonies, a scientific and technological base from where it could take off after Independence provided the political leadership gave it the necessary support. This is what happened after Independence.

SCIENTIFIC AND TECHNICAL EDUCATION

POST-INDEPENDENCE ERA

India realised at the dawn of her Independence that it cannot develop as a nation and achieve the goals for which the national movement had fought -- of meeting the needs of people and enabling them to have a better life - without educating her people. The objectives were to remove illiteracy and provide education to all. The latter is a part of her Constitution. As a result, soon after Independence a series of Commissions were constituted to provide advice to the Government for the reorganisation and development of education.

The development of university education has been guided by the reports of the Sargent Committee, the University Education Commission (1948-49), Secondary Education Commission (1952-53) and the Education Commission (1964-66).

The Report of the Central Advisory Board of Education on Post-war Educational Development, headed by Sargent, indicated the broad lines of expansion of education. The University Education Commission, headed by Dr. S. Radhakrishnan (later Vice-President and President of the Republic of India), drew up the blueprint for the university education in free India. One of its major recommendations was the establishment of a University Grants Commission. The Commission was to support the universities, particularly its research programmes and to guide their future development. The Secondary Education Commission's major recommendation was with regard to the structure of the degree course.

The Education Commission (1964-66) headed by Dr. D.S. Kothari, the eminent scientist, surveyed the developments since Independence, identified the new needs, and made specific suggestions to meet the requirements including the scale of investment in education. It made specific recommendations with regard to promotion of science, particularly mathematics at the universities.

There has been a phenomenal increase in the number of universities since Independence. In 1947, there were only 19 universities in the country. After 1947, there was major expansion in terms of numbers. For instance, by 1960, 45 universities had

been established. By 1970, the total number had risen to 83. Presently the number of universities is 121; in addition, 13 institutions are deemed to be universities, and 9 institutions are recognised as of national importance. There are 21 agricultural universities. To start with they were modelled on the Land Grant pattern of the United States. With the passage of time, however, their character has undergone some changes. Every State is expected to have one agriculture university.

With this magnitude of educational activity, expenditure on science and education has also gone up. Education is a State as well as Central Government subject. The States contribute some portion of expenditure incurred by the universities whereas the University Grants Commission (UGC) contributes the rest. For some activities like maintenance of centres of advanced studies, summer schools, conferences and seminars, the entire expenditure is met by the UGC.

SCIENTIFIC AND TECHNICAL MANPOWER

The enrolment in science subjects has increased considerably. Tables 1 & 2 give an idea of the development of scientific and technological personnel since Independence.

As the manpower grew, it made it possible to further develop the educational institutions, develop newer areas of teaching and research and made it possible to create and allow the R&D institutions to grow and to reach a critical level, necessary for them to become self-generating.

IMPROVEMENT OF THE UNIVERSITY EDUCATION

With the assistance and funds from the University Grants Commission, the universities were able to organise summer schools to improve the professional competence of teachers by acquainting them with current developments in their respective fields of knowledge, modern curricula and new techniques of instructions. From time to time review committees were appointed to examine

TABLE 1 : STUDENTS ENROLMENT IN UNIVERSITIES 1969-70 TO 1982-83

Subject	1969-70	1975-76	1979-80	1980-81	1981-82	1982-83 (Estimated)
Science	449778	463841	508763	533859	578766	619100
Engg/Technology	87465	96067	118607	128937	130189	142583
Medicine	78577	105140	112194	110020	113794	116893
Agriculture	22581	30160	39962	39231	39318	40139
Veterinary	5325	6377	7435	7648	8173	8732
Total:	643726	701585	786961	819695	870240	927447

Source: University Grants Commission, New Delhi.

TABLE 2 : STOCK OF SCIENTIFIC AND TECHNICAL PERSONNEL 1950-1985

Category of Personnel	Stock at the end of the year (000)						
	1950	1955	1960	1965	1970	1980 Estimated	1985 Estimated
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(a)Engineering and Technology:							
i)Degree	21.6	37.5	62.2	106.7	185.4	221.4	266.3
ii)Diploma	31.5	46.8	75.0	138.9	244.4	329.4	429.9
(b)Science:							
i)Post Graduates	16.0	28.0	47.7	85.7	139.2	217.5	273.0
ii)Graduates	60.0	102.9	165.6	261.5	420.0	750.3	956.5
(c)Agriculture:							
i)Post Graduates	1.0	2.0	3.7	7.7	13.5	96.5	114.1
ii)Graduates	6.9	11.5	20.2	39.4	47.2	-	-
(d)Medicine:							
i)Degree	18.0	29.0	41.6	60.6	97.8	167.6	198.7
ii)Licentiates	33.0	35.0	34.0	31.0	27.0	N.A.	N.A.
Total	188.0	292.7	450.0	731.5	1174.5	1782.70	2238.5

Source: Columns (2) to (6) Division of Scientific & Technical Personnel, CSIR. Cols. (7) & (8) Sixth Five Year Plan, 1980-85 Planning Commission.

Note: During the years 1980 & 1985, the numbers or BScs who were also BEds were estimated to be 1.66 lakhs and 2.28 lakhs. Similar figures for the earlier years are not available.

curricula, and for in-depth teaching of different subjects. Reports of review committees are published occasionally. Travel grants are provided to teachers for visiting centres of research and advanced study so that the teachers are kept informed of the latest developments in their subjects of teaching and specialisation. This assistance, coupled with that made available by research agencies, enabled the Universities to establish schools of research and also made possible a large number of students to be trained as research scientists in advanced and frontier areas of science and technology.

RESEARCH SCHEMES

Considerable scientific research is conducted in different branches of science and technology in the universities. The Council of Scientific and Industrial Research, University Grants Commission, Indian National Science Academy, Atomic Energy Commission, Indian Council of Agricultural Research and Indian Council of Medical Research and other agencies and institutions offer financial support for specific and meaningful projects. Senior and Junior Research Fellowships on a large scale are awarded every year to help scholars conduct research work on specific projects for a period of around two years. Thus, with the support of these national agencies and sometimes with those of international agencies research content in universities has increased considerably.

PROFESSIONAL EDUCATION

ENGINEERING

The last two decades have brought about significant advances in all fields of technical and technological education in the country.

The expansion of facilities at diploma level has also been considerable. Diploma holders are middle level specialists having undergone, three year courses in polytechnics.

One aspect of qualitative improvement is the creation of facilities for postgraduate study and research in various branches of engineering and technology. Such facilities were almost non-existent before 1947. Presently, a large number of institutions offer such courses in a variety of subjects.

Another step forward in the same direction was the establishment of higher technological institutes. On the lines of M.I.T. (USA) and Federal Technological Institute at Zurich, five Institutes of Technology were established to serve the nation by training the highest grades of technologists and engineers and by disseminating advances in scientific and technical knowledge. Apart from imparting instructions in their respective professional specialised subjects, there was provision for broad-based education which was expected to turn out mature scholars eventually to act as leaders in different fields. Thus, they had faculties not only in

fundamental sciences and various technologies but also in the humanities and social sciences. The four institutes which were established were at Kharagpur (West Bengal), Kanpur (U.P.), Madras, Bombay and Delhi. They have facilities to provide education and training to over 6500 students in undergraduate courses, over 3200 students in postgraduate courses and over 2300 students for research work. All these are residential institutions.

The Indian Institute of Science, Bangalore was founded by the House of Tatas in 1911. The Government of India decided that the institute should offer facilities for advance studies and research. Since then, it has developed many faculties of engineering and technology. University of Roorkee, originally established as Thomason College of Engineering in the middle of the 19th century, was developed into a full-fledged university.

MANAGEMENT TRAINING

Development of managerial and supervisory manpower is also receiving considerable emphasis. Agencies like the Administrative Staff College of India like, Indian Institute of Management at Calcutta, Ahmedabad and Bangalore, National Productivity Council, etc. frequently organise courses, seminars and workshops on management training of students in this field as well as for employed personnel, entrepreneurs and managers. Modern scientific techniques of management, which enhance productivity, have become popular and institutions and industries are taking full advantage of these. The institutes of management offer a variety of short-term and other regular courses for different level executives to improve their competence and quality.

IN-SERVICE EDUCATION

Apart from formal university education, in-service education and training has been receiving attention from various agencies. Several technological universities and colleges offer short term refresher courses and specialist courses for the newly developing technological fields. These provide latest know-how and keep the professionals in touch with the modern trends. The idea is catching up faster and employers are increasingly deputing their staff members to such courses.

Certain professional societies contribute to the educational effort in the interest of their members. For example, the Institution of Engineers (India), Operational Research Society of India and other similar organisations offer this facility for lesser qualified members, who are skilled technicians and workers engaged in various technical jobs, to improve their capabilities and career opportunities. The Government has given due recognition to such qualifications. Thus, career openings are created for competent professionals which serve as a big incentive for them.

MEDICINE

There were 30 medical colleges in 1950-51 with a total enrolment of 2,500. In 1977-78, the number of colleges of modern medicine stood at 106 with an admission capacity of 12,500. Besides there are institutions imparting medical education in the Indian systems of medicine. There are 90 ayurvedic, 15 unani and one siddha institutions. Total enrolment for various courses during the year 1979-80 was 1,12,194.

The post-graduate courses and research facilities were of a very low order in 1947. With the all-round development the qualitative aspect has not been ignored. As an example, in twelve years (1957-58 to 1969-70) the enrolment in postgraduate courses has gone up by over 300 per cent and that for research by 200 per cent. The Government is supporting the research activity considerably and has established some centres of national importance. These are, All India Institute of Medical Sciences, New Delhi and Postgraduate Institute of Medical Education and Research, Chandigarh. Besides, encouragement is given to several specialist centres and research and training programmes through the Indian Council of Medical Research, University Grants Commission and State Governments.

The Indian Council of Medical Research, being a premier organisation in this field, provides training and research facilities in several specialised fields at its various institutions. The National Institute of Nutrition, Hyderabad for instance, besides carrying out research provides facilities for training as well. Public health workers and community development workers are also trained to enable them to effectively participate in nutrition action programmes. Similarly, advanced training courses are organised at the National Institute of Communicable Diseases, Delhi in the field of epidemiology, malariology and entomology. Various private and governmental institutions like All India Institute of Physical Medicine and Rehabilitation, Bombay; All India Institute of Hygiene and Public Health, Calcutta; the Cholera Research Centre, Calcutta; the Virus Research Centre, etc. also undertake similar education, training and research programmes in their own fields of specialisation.

The Government gives liberal aid for all these activities. Besides the Medical Council of India there are three other statutory councils to look into the educational and other aspects in different fields. The Pharmacy Council of India enforces the educational standards, and takes other steps to further the training facilities for pharmacy courses. Besides degree level institutions, till 1970 there were 34 institutions imparting education at diploma level courses with an annual intake capacity of 1,750 students. The Dental Council of India also undertakes similar responsibilities in

the field of dental education. In 1980 there were 15 dental colleges in India with an annual admission capacity of 600. The Indian Nursing Council looks into various aspects of nursing education. Education and training of nurses is conducted at several institutions. There were 614 degree and diploma schools and colleges in nursing (1980).

The increase in the population of India (primarily due to lowering of death rate) and the effect it has on development and meeting the needs of people and providing them facilities and amenities has created an urgent need for control of population. Consequently training and teaching programme in the field of family planning has been receiving considerable emphasis in recent years. There are 5 central training institutions and 45 regional training centres located in various States in the country. In the year 1970-71 alone, 265 qualified persons were trained to act as supervisory personnel, such as State Family Planning Officers, district extension eduators, trainers of the regional training centres and officers of the Central Family Planning Corps.

AGRICULTURE AND VETERINARY SCIENCES

There is a nation wide system of formal and informal education devoted to agriculture. Courses of higher education are offered at various agricultural universities as well as at some other institutions. A considerable number of technical agencies serve agriculture at both Central as well as State levels.

In 1950-51 there were only 16 colleges offering degree courses in agriculture with a total enrolment of 4,744. In 1979-80 the number of affiliated and university colleges was 52. Besides, there are about 20 more general educational multifaculty institutions imparting degree level education in agriculture. The total enrolment was 39,962. With the increase in number of colleges the total enrolment has gone up by about 8-fold during a span of about 30 years.

Prior to 1947, very few facilities were available for postgraduate courses and research work and no exclusive higher educational institutions or agricultural universities were established. The Indian Agricultural Research Institute at New Delhi was a premier organisation conducting R&D activities in this field. With increasing emphasis on postgraduate training and research it was recognised as an institution deemed to be a university in 1958. This was the first exclusive university level institution for agriculture. Since 1960, as many as 21 agricultural universities have been established by Acts of State Legislatures. These universities cover the fields of teaching, research and extension. They depend on Indian Council of Agricultural Research (ICAR), State Government and certain other agencies for their

financial support. Extension of work done in laboratories or experimental farms is one of the major activities of agricultural universities. New farming methods, improved hybird seeds, proper rotation of crops, better tools, use of chemical fertilisers etc. are some of the gifts from the University to the farmers. This has brought about a revolution in agriculture which was more or less primitive in its ways till recently.

The informal aspects of agricultural education today are embodied in the new programmes of extension, in the activities of State and Central agencies of agriculture and in the growing number of business and industrial concerns which offer services and informal education as part of their commercial activities.

The educational facilities in the fields of veterinary sciences were not sufficiently developed even in early fifties. Hence priority was given to the teaching and extension activities in this vital sector in the first and second Five Year Plans. The magnitude of emphasis could be gauged from the fact that expenditure in the First Plan towards education and training was Rs. 3 million whereas it swelled to over Rs. 23 million in the Third Plan. Veterinary training including postgraduate and doctorate training is imparted at 22 veterinary colleges. In 1950 the outturn of veterinary graduates was only 100. But, the intake of existing colleges was increased and new institutions were established. The enrolment figure in veterinary sciences has gone to up to 7,435 in 1980. Even short-term programmes of two years duration were organised in certain States to meet the growing demand. In 1980, there were 22 institutions with postgraduate teaching and training programmes distributed in nine States. A variety of subjects for specialisation in different branches of veterinary sciences were available at these institutions.

With growing consciousness and consequent emphasis on agriculture, animal husbandry and dairy products, it is expected that the country would become self-sufficient in food and dairy products in the near future.

ORGANISATION OF SCIENTIFIC RESEARCH

Scientific and technological research, covering a large number of areas of science and technology, has developed rapidly since independence. Firstly, those institutions, which were established before independence, were reorganised to meet new requirements and expanded considerably to undertake and discharge their new responsibilities. Resources were provided to them to enable them to attract scientists and technologists and equip them adequately. Despite limitations, foreign exchange was liberally provided to enable them to import vital equipment for research.

In addition to developing the already established, new institutions were created to cover newer areas of science and technology. In the creation of new institutions, advice was taken from advanced countries and their experience of institutional research was also taken into consideration. There was, however, considerable experimentation both with the nature of organisation and structure. The major consideration in doing so was to meet two requirements:

Firstly, to provide them functional autonomy, so as to free them from bureaucratic control and enable them to undertake imaginative and bold programmes of research. Secondly, to make them accountable, both with regard to utilization of resources made available and the fulfilment of their scientific and technical programmes.

In the context of these objectives and policies six types of institutions were developed:

1. Autonomous Organisations were created as societies. These organisations, though they received their entire funds from the government, framed their rules and regulations with regard to their research programmes, recruitment of scientific and technical personnel and procedures for utilisation of resources and accountability. In this category, the institutions are: Council of Scientific & Industrial Research, Indian Council for Agricultural Research, and Indian Council for Medical Research, and others. These have their Governing Bodies, and Research Advisory Committees who look into broad problems of their development and are composed of eminent scientists as well as ministers, who are responsible for them at the Parliament level.

2. Special Department/Commissions, headed by eminent scientists, were created to cover new and emerging areas of science and technology. The Commissions decided broad policies and programmes. These were supported by Departments of the Government. The Chairman of the Commission was made Secretary to the Department and was directly responsible to the Minister concerned to allow for their smooth functioning. Among these, the oldest is Atomic Energy Commission; it was followed by a Commission for Electronics, then for Space and the last one to be created was for Additional Sources of Energy . Also special Departments were created in areas of Environment and Ocean Development.

3. Institutions under Ministries. The old pattern of Ministries having institutions under them to carry out research in specific areas was continued, like those in agriculture, health, education, industry and railways etc. Only their scope was enlarged in the context of new demands and requirements and more resources were made available to them. A new addition to these was the Department of Science and Technology. This was established to coordinate research, spread over different agencies and departments, and take new initiative where it was found necessary.

4. Industrial R&D Establishments. Industry was encouraged to establish captive research institutions to meet the day-to-day requirements of production and technological improvements. Industry in India is both public as well as privately owned. The government gave large grants for the establishments of research and development for the public sector industry; to the private sector industry, it gave tax concession for research.

5. Cooperative Research Associations. A beginning was made by covering the area of textiles including man-made fibres; four Cooperative Research Associations were formed by industry with the encouragement and financial support of Government to the extent of 50% of their expenses. In order to support research and development, cess was introduced in industry and the money so collected was used for funding research and development activities for the industry, such as in the case of cement.

6. Private Institutions. The government also provided incentives to people to invest in research by providing tax exemption if the money was to be invested for educational purposes or for research. As a result of this policy a large number of societies, foundations, trusts

were established in the country. These provided fellowships or grants for research or established educational or research institutions with specific objectives. The number of such institutions is very large in the country.

The major portion of the research is being managed by the organisations, namely Council of Scientific & Industrial Research (CSIR), Indian Council of Agricultural Research (ICAR), Indian Council of Medical Research (ICMR), Defence Research & Development Organisation (DRDO) , Department of Atomic Energy (DAE) and Department of Space; these are responsible for research in industry, agriculture, medicine, defence, atomic energy and space respectively. The main function of these organisations is to support and coordinate research in their respective areas. This is carried out through the establishment of specialised research institutes as well as through research grants to institutions and award of fellowships to students.

A good deal of research in fields like irrigation, power, railways, telecommunications, broadcasting, meteorology, civil aviation, petroleum etc. is being done in institutes directly controlled by the ministries. Research in botany, zoology, geology, anthropology, etc. is the responsibility of the respective scientific surveys, which are under various ministries.

State Governments are concentrating primarily on research in agriculture, animal husbandry, public health, irrigation, forestry, agriculture etc. The State Governments have now also established State Committees of Science & Technology to promote research and to help in finding solutions to the specific problems faced by them.

Research in universities is supported by the University Grants Commission (UGC). In addition, a few of the industrial units have their own laboratories for undertaking research in their respective fields.

A brief account of the structure and functions of each organisation is described below:

COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH

The Council of Scientific and Industrial Research (CSIR), constituted in 1942 by a resolution of the then Central Legislative Assembly, is an autonomous body registered under the Registration of Societies Act XXI of 1860. The functions assigned to the Council are:

(1) promotion, guidance and coordination of scientific and industrial research in India, including the institution and financing of specific researches; (2) establishment or development of and assistance to special institutions or departments of existing institutions for scientific study of problems affecting particular

industries and trades; (3) establishment and award of research studentships and fellowships; (4) utilization of the results of the researches conducted under the auspices of the Council towards the development of industries in the country; (5) establishment, maintenance and management of laboratories, workshops, institutes and organizations to further scientific and industrial research and to utilize and exploit for purposes of experiment or otherwise any discovery or invention likely to be of use to Indian industries; (6) collection and dissemination of information in regard not only to research but also to industrial matters generally; (7) publication of scientific papers and journals; and (8) any other activity or activities to promote generally the objects of the resolution.

The Society of the Council of Scientific and Industrial Research consists of the following members: (1) the Prime Minister of India, who shall be the ex-officio President of the Society; (2) the Minister-in-charge of the Ministry or Department dealing with the Council of Scientific and Industrial Research, who is the ex-officio Vice President of the Society. Provided that during any period when the Prime Minister is also such Minister, any person nominated in this behalf by the Prime Minister shall be the Vice President; (3) the members of the Governing Body; and (4) any other person or persons appointed by the Government of India.

The authorities of the Society are: the Governing Body, the President of the Society, the Vice President of the Society, the Director General of Scientific & Industrial Research, and such other authorities as may be constituted by the Governing Body.

The affairs of the Society are administered, directed and controlled, subject to the rules and regulations and by-laws and orders of the Society, by a Governing Body. The Governing Body of the Society for the purpose of Act XXI of 1860 shall consist of the following members: (1) the Director General, Scientific & Industrial Research, who is the ex-officio Chairman of the Governing Body; (2) five Directors of the laboratories who are Chairmen of Coordination Councils; (3) Member, Finance, who shall be Secretary to the Government of India (for financial matters concerning CSIR); and (4) three experts nominated by the President of the Society from outside the Council of Scientific and Industrial Research. The Governing Body meets as often as may be considered necessary but not less than four times a year.

The Director General of Scientific & Industrial Research, is the Chairman of the Governing Body of CSIR. He is Secretary to the Government of India. He is the Principal Executive Officer of the Society. He is ex-officio Secretary to the Society of CSIR. Apart from the Director General, the officers of the Society are the Directors of the national laboratories and such other officers as may be appointed from time to time by the authority competent

to make the appointment to assist the Director General and the Directors of national laboratories and for carrying out the objects set forth in the Memmorandum of Association.

The Director General of Scientific and Industrial Research is the principal Executive Officer of the Council and is responsible for the proper administration and affairs of the Society under the direction and guidance of the President, the Vice President and the Society. His responsibilities include coordinating and exercising general supervision over all scientific and industrial researches and other activities of CSIR.

The Director General is assisted in his work by a number of technical and administrative Divisions and Units at the headquarters, viz. Planning, Manpower, Technology Utilization, Extramural Research, International Collaboration, Information & Public Relations, Administration, and Finance.

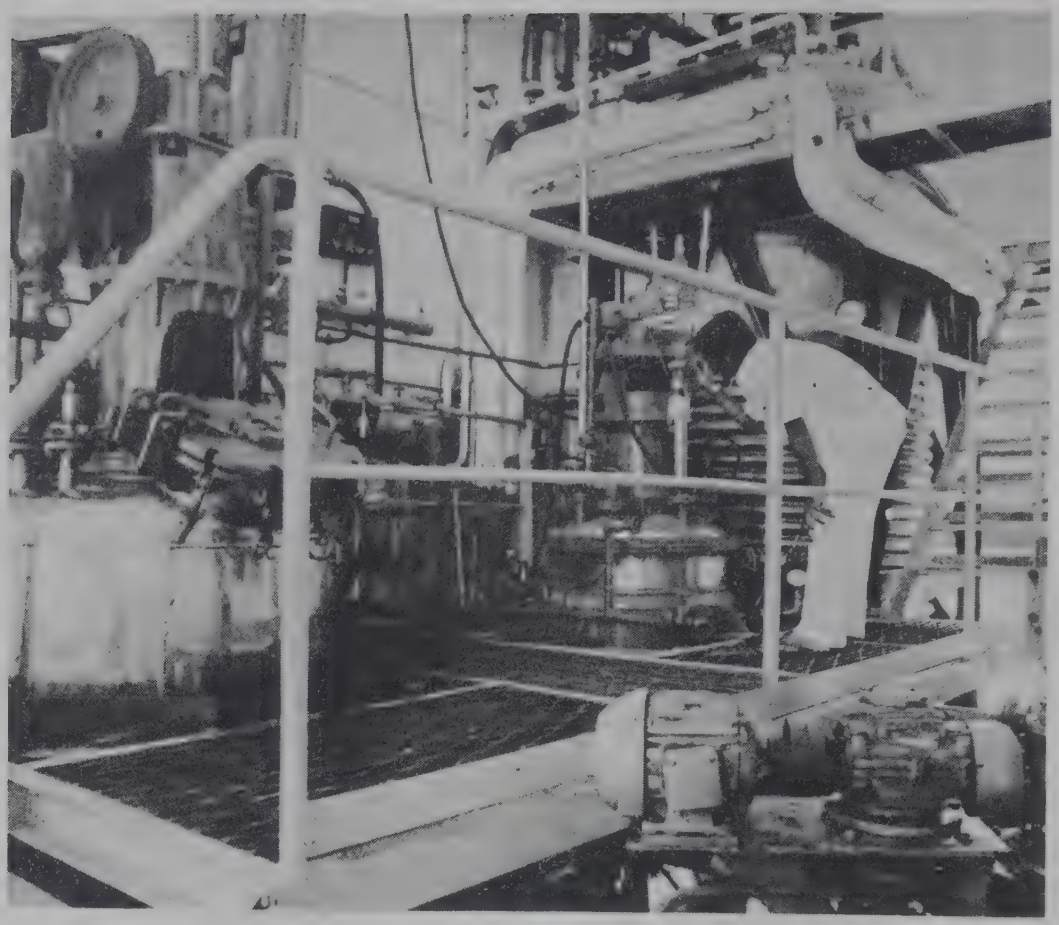
The Council supports research in universities and other institutions of higher learning by providing grants for research schemes--an activity started by CSIR since its inception in 1942. This sustained assistance provided by CSIR has considerably contributed to the pursuit and progress of research activities in various departments of universities,institutes of technologies (IITs), postgraduate departments and colleges, and indirectly helped in the establishment of the scientific base in the country. Such assistance has also helped strengthen research facilities and train research personnel in different fields of science, technology and engineering in academic institutions.

With a view to developing closer relations with other friendly countries in the field of science and technology, CSIR enters into bilateral agreements/protocols for exchange of scientists as also for scientific and technical cooperation.

The CSIR now supports 38 national laboratories/institutes, 3 complexes and 2 research associations. Some of the research establishments are engaged in research activities which are basic to industrial advancement. Other laboratories deal with the nation's general needs with regard to food, fuel, buildings, and roads. Some are concerned with problems of interest to specific industries, as for instance electronics, glass and ceramics, leather, minerals and metals, marine chemicals, drugs, and scientific instruments. There are establishments concerned with research in mechanical engineering, aeronautical engineering, environmental engineering, electrochemistry, geophysics, oceanography, experimental medicine, and toxicology.

CONTRIBUTION TO INDUSTRIAL DEVELOPMENT

The current activities encompass the establishment of capability and generation of technological know-how over a wide



Tromaril Plant at M/S UNICHEM

Glyoxal Plant at M/S Rajasthan Glyoxal

spectrum of science and technology. CSIR assists industry in technology development and updating, import substitution, cost reduction, energy conservation, waste utilisation, pollution control, repair and maintenance, and trouble-shooting. CSIR also conducts research and development in areas of national priority with a long-term impact, and of varying size or complexity, requiring multi-agency cooperation. At present, these projects are in the areas of aeronautics, microelectronics, biotechnology, coal, ocean science, and information technology which are vital to the national security and the well being and economic growth of the country. Further, initiative has been taken in developing competance and promoting studies relating to problems concerned with science and technology in development, technology forecasting and assessment.

CHEMICALS AND CHEMICAL ENGINEERING

The major impact of technologies on organised industry has been mainly in the chemical and related sectors. Out of 536 enterprises which have gone into production during 1977 - 83, about 40 per cent are in the chemical sector; and of the 295 technologies productionised in this period, over 40 per cent are from the chemical industry. The activities in the area of chemicals and chemical engineering cover a wide spectrum: inorganic and organic chemicals, drugs and pharmaceuticals, pesticides and their intermediates, coal chemicals, besides surface coatings, corrosion prevention chemicals, catalysts, etc. A number of processes have been developed and released to industries for setting up plants on chlorosilanes, glyoxal, benzyl chemicals and beta-naphthol. Based on CSIR know-how, the first plant in Asia for chlorosilanes, of 1000 tonnes per annum (TPA) capacity, at a cost of Rs. 80 million has been put up by HICO at Kharsundi. For glyoxal, a 900 TPA plant, the first of its kind in India, has been put up by Davy Power Gas (India) Ltd. Similarily in the case of beta-naphthol technology, Eastern Naphthas Chemical Ltd. has put up the first plant in India to use sulphonation of aromatics. CSIR has also worked out processes for the exploitation of marine resources for the manufacture of inorganic chemicals such as for potassium schoenite, potassium silicate and potassium chlorate, and hydrazine hydrate, etc. A 1000 TPA electrolytic manganese dioxide (EMD) has been put up and working since 1977. Another EMD plant of 3000 TPA is being set up.

DRUGS AND PHARMACEUTICALS

In the area of drugs and pharmaceuticals--an area dominated by process patents of multinationals, work was concentrated both on the synthesis of new drugs, and on development of known drugs and their intermediates. Two new non-steroidal anti-inflammatory

and anti-rheumatic drugs, viz. N-beta-phenylethylanthranilic acid (Enfenamic acid) and Salai guggal (ex-Boswellia serrata) have been developed, and these are are presently marketed under the trade names TROMARIL and SALLAKI. Aminophylline and theophylline were manufactured for the first time in India. Processes for manufacture of a variety of bulk drugs have been developed such as anti-asthmatic drug salbutamola, anti-rheumatoid drug Ibuprofen, anti-cancer drugs vincristine and vinblastin. An improved proces for vitamin B_6 and rutin has also been developed. Several drug intermediates are also manufactured with know-how developed by CSIR. A 2000 TPA plant for the manufacture of acetanilide has been put up by Hindustan Organic Chemicals Ltd. This is the first plant for manufacture of a drug intermediate to have been put up in Asia. Besides, scientific cultivation of medicinal plants, known for active constituents of medical value or essential oils, has been propagated.

FOOD AND BEVERAGES

The development of nutritious foods like infant and weaning foods, as well as proein enrichment beverages from unconventional sources like groundnut, has been a major area of activity. Technology for the production of baby food from buffallo milk had been responsible for establishment of a radically new baby food industry in the country. Improvments have also been made at every step of food grain processes such as milling, parboiling, drying and curing, which have helped in obtaining better yields and in quality improvement. The technology for parboiling of paddy is being used by 500 rice mills in the country.

PESTICIDES

Technologies for a wide range of pesticides including insecticides, herbicides, fungicides/miticides etc. and their intermediates have been developed. A process know-how for Monocrotophos has been used by NOCIL to put a Rs. 170 million, 500 TPA plant at Ratnagiri, commissioned in early 1983. This is expected to save about Rs. 40 million of foreign exchange annualy. JKBM's 300 TPA MBC fungicide plant, Shaw Wallace and Micro Farm plants for dimethoate and Sundarshan Chemical's multipurpose pesticide plants at Raha for Quinalphos, Monocrotophos and Phosphomidon are the other major pesticide units established with know-how developed in the laboratories.

ELECTRONICS AND INSTRUMENTATION

A very wide range of instruments from comparatively simple instruments to sensitive and highly sophisticated have been developed. These are spread over numerous areas like process-control, agro-dairying, medical, optical, geophysical,

Tools & Equipments used in Cottage Level Production of Fish-Hooks

L.T.C. Plant

marine, electrochemical, etc. In the area of process control instrumentation, design and development work is under way on a microprocessor based integrated electronic process control system for small and medium chemical industries for monitoring, controlling and displaying the status of different process parameters. Concentrated developments on process control instruments for sugar, paper pulp and textiles industry have been taken up, which have resulted in considerably improving the efficiency of production. Instruments developed for sugar industry have already been adopted by over 300 sugar mills. Considerable work has been completed on a programme sequence control systems which is of vital importance to power plants. A range of agro-dairying electronic instruments with digital readouts have been taken for development. Technical know-how has been released to industry for a number of medical instruments. viz patient monitoring system, foetus stethoscope, cardiac monitor, CCTV system, etc. For a significant number of optical instruments, know-how such as for bubble chamber scanner, prismatic binocular, microfilm reader etc. has also been passed on to industry. Among the geophysical instruments, prerequisites for geographical surveys, a notable development is that of airborne pulse transient electromagnetic equipment which is superior to other commercially available foreign systems and has a much better signal-to-noise ratio.

CIVIL ENGINEERING

The contribution to civil engineering field has been mainly through evolution of new designs, techniques, and practices for design, construction and engineering. Thus, discrete technologies adopted by industry account for only 6% of the total technologies. The high draught (HD) kiln developed has replaced the conventional bull's - trench kiln and has proved to be an outstanding success because of its high thermal efficiency. This HD kiln used along with a semi-mechanised brick making machine, also developed by CSIR, leads to a low capital and high profitability investment. These machines replaced fully mechanised imported machines but yet return many of their advantages. These machines have found wide acceptance in the brick industry.

OTHER AREAS

Significant advances have been made in the technologies for utilisation of coal by low-temperature coal carbonisation. The Council has on hand a programme for developing technologies for conversion of coal into fuel gas, synthesis gas and liquid fuels. Major contributions have been made in the development of machinery and equipment, metals and alloys, glass and ceramics.

Indigenous Manufacturing Process of Bell and Brass Metal Utensil Casting

Efforts are now directed towards developing newer materials. In the area of industrial machinery know-how has been passed on to industry in the field of farm and agriculture equipment, machine tools, leather machinery, mining machinery, etc. A significant example of the know-how developed is Swaraj Tractor. A prototype of 10/15 hp tractor has also been developed.

CSIR has also provided a major contribution towards oceanography research in India mainly in the area of location and processing of nodules and towards the nation's success in the Antarctica research.

Pioneering work has been done on carbon products, especially extruded ones, viz. cinema arc carbons, process carbons and midget electrodes. The technology for the development of cinema arc carbons has attracted the attention of other developing countries. CSIR has also developed carbon brushes and micrographic carbon granules. Other important areas of CSIR contribution to industry are energy, environment, aeronautics, space, defence research etc.

The contribution towards rural industries is also well recognized. A number of processes have been developed in the area of leather, ceramics and pottery, pulp and paper, agro and forest resource based, metal based and engineering industries suited to the needs of the rural industry.

Major experiments towards the utilisation and the social and cultural acceptance of the CSIR rural technologies have been tried by adopting a village Karimnagar. An interesting experiment has been carried out by NISTADS towards developing better linkages between the laboratory scientists and rural community. The experiment has focused attention mainly on the rural industries and the village artisans and has been trying to familiarise the latter with the developments of science and technology in their areas of interest with the help of scientists and technologists from the laboratories. To begin with, a series of workshops have been organized in different rural areas to promote effective interaction between the village artisans, scientific community and the other scientific institutions as well as the voluntary organisations and government institutions doing development work. The intention was to prepare ground step by step, for forging a link between the indigenous R&D activities and the village artisan production and its clientele, landless labourers, and small and marginal farmers. Consequent on the success of these workshops and the enthusiasm they generated among the participants, the NISTADS perceived the need for setting up of an infrastructure for working with the village artisans.

The regional laboratories are concerned basically with problems of industrial development in their respective geographical areas, but do undertake projects of national relevance. CSIR has also established a National Institute of Science, Technology and

Development Studies to undertake studies on science policy and science and society interface. This is an interesting and an important departure for the area which was not considered till recently a part of natural science. Besides these, two CSIR establishments are concerned with the publication and dissemination of scientific and technical information. The Council has taken active interest in the formation of research associations of industries. It renders assistance to industries which are desirous of forming research associations, by way of technical advice, preparing plans and procuring materials and experts wherever necessary. The Council provides financial assistance towards both capital and recurring expenditure.

Each research establishment has an Executive Committee responsible for the control and general direction of its activities, and a Research Advisory Council which advises the Executive Committee.

To ensure inter-laboratory collaboration to the maximum extent, the Council's laboratories and the cooperative research associations are grouped under five Coordination Councils, viz. Physical & Earth Sciences; Chemical Sciences; Biological Sciences; Engineering Sciences; and Information Sciences. The Coordination Councils promote inter-laboratory, inter-industry and laboratory-university task projects and allocate priorities and evaluate the progress of collaborative projects.

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

On the basis of various recommendations made by the Royal Commission on Agriculture in 1928, the Government of India decided to set up the Imperial Council of Agricultural Research as a Society. The Council was accordingly registered as a Society under the Societies Registration Act, 1860 on July 16, 1929, which was renamed as Indian Council of Agricultural Research on June 10, 1947.

The broad aims and objectives of the Council are:

(1) to undertake, aid, promote and coordinate agricultural and animal husbandry, education, research and its application in practice, development and marketing by all means calculated to increase scientific knowledge of the subjects and to secure its adoption in everyday practice;

(2) to act as a clearing house of information not only in regard to research but also in regard to agricultural and veterinary matters generally;

(3) to establish and maintain a research and reference library in pursuance of the objects of the society with reading and writing rooms and to furnish the same with books, reviews, magazines, newspapers and other publications; and

A Double-Dwarf, High Yielding Wheat Variety, HD-2285

Standing Crop of a High Yielding Semi-Dwarf Rice Variety, Pusa 169

(4) to do all other such things as the Society may consider necessary, incidential or conductive to attainment of the above objects.

From time to time, various expert committees and teams recommended the reorganisation of the research activities of the Council. The restructuring of the ICAR in 1965-66 was a landmark. The Governing Body of the Council was reconstituted and a career scientist was appointed as the Director-General and Vice-President of the Council - a departure from the tradition of appointing only a member of the administrative service to this post. To assist the Director-General on the technical side, four posts of Deputy Director-General were created and filled by eminent scientists i.e. one each for (a) Crop Sciences, (b) Soils, Agronomy, Irrigation, Agricultural Engineering, (c) Animal Sciences, and (d) Education. The rules and bye-laws of the Council were also revised to make it more truly a functional, technically competent and adequately autonomous organisation.

At present, the Union Minister for Agriculture is the President of the Council, and the Minister of State in the Ministry dealing with ICAR affairs is the Vice-President. The Council functions through a Governing Body which is presided over by the Director-General of the Council, is also Secretary to the Department of Agriculture Research and Education of the Government of India. Besides the Governing Body there are Standing Finance Committee, the Norms and Accreditation Committee, Regional Committees,and the Scientific Panels.

Under the Council are 33 research institutes and four project directorates. The Council deals with 21 agricultural universities in addition to the Indian Agricultural Research Institute, which has the status of a post-graduate university. The Council is running a large number of all India coordinated research projects on food crops, commercial crops, horticultural crops; on soil, agronomy and agricultural engineering, breeding and improvement of the important farm animals and also in the field of fisheries.

In recent years the need for close cooperation with other scientific organisations has been felt and the ICAR now has Joint Panels with the Council of Scientific and Industrial Research, the Indian Council of Medical Research, the Indian Council of Social Science Research, the India Meteorological Department, Department of Atomic Energy, Space and Electronics, Defence Research and Development Organisation, University Grants Commission and the Indian National Science Academy.

In the era before Independence, foreign experts in agriculture and animal husbandry were drawn from the United Kingdom. Soon after Independence, large scale collaboration in the field of research and education with U.S.A. was in progress for some years. After that the cooperation became truly international and

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many other countries including the USSR, Canada, Australia and Japan have cooperated with the Council in various fields of endeavour. A number of the United Nations agencies like FAO and UNDP have participated or assisted in the progress of research, education and extension; also the World Bank.

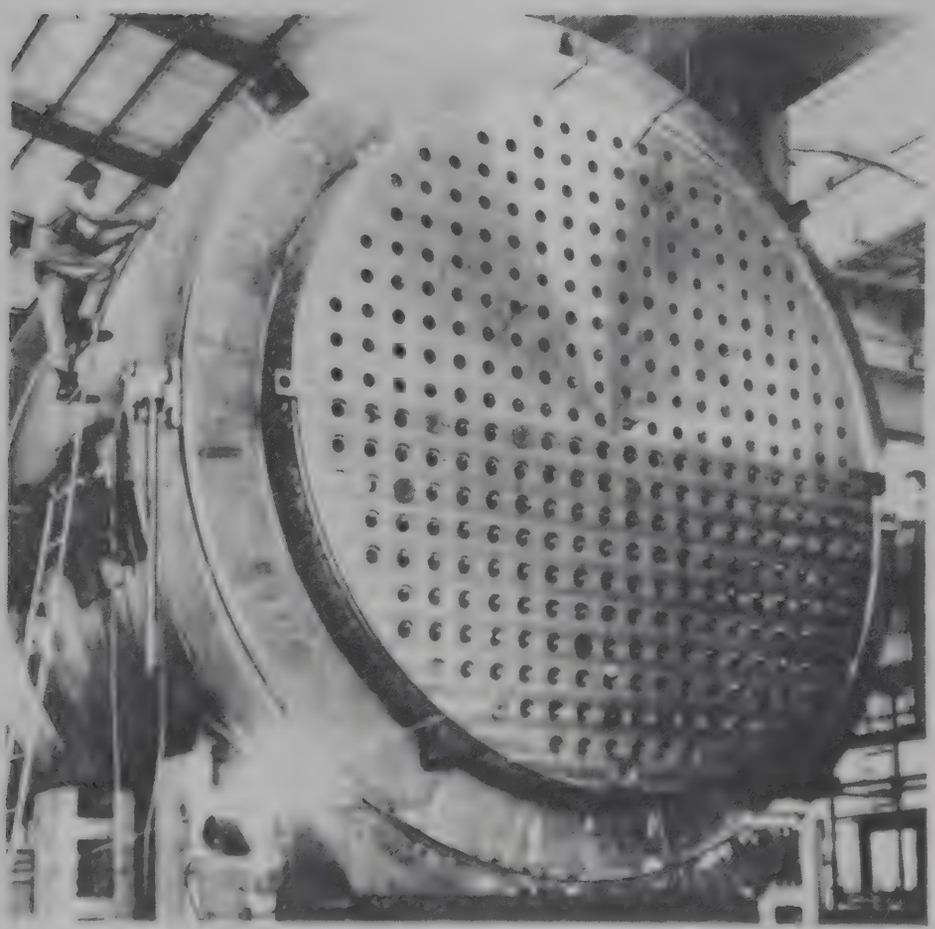
INDIAN COUNCIL OF MEDICAL RESEARCH

The Indian Research Fund Association was established in 1911 for supporting research in the field of communicable diseases, such as malaria, plague, smallpox and cholera. After independence, there were several changes both in organisation and in the activities of the Indian Research Fund Association. A big change took place in 1949 when the Association was rechristened as the Indian Council of Medical Research. ICMR is the apex body in India for the formation, coordination and promotion of biomedical research, discharges its primary function of promoting biomedical research mainly through its permanent research institutes/ centres/regional medical research centres/centres of advanced research, national multicentric coordinated projects and through a large number of ad-hoc research schemes, generated by working scientists, in biomedical institutions/universities in India. A major goal of ICMR is to strengthen indigenous capability and develop a broad-based and balanced cadre of able research personnel and facilities to cope with the present/oncoming health problems of India. Some of the significant areas of ICMR research are tuberculosis, leprosy, cholera and enteric diseases, nutritional disorders and nutritional surveys, facility regulation and the investigation of viral disease like the Kyasanur forest disease, dengue and Japanese encephalitis.

The affairs of the Council are managed by a Governing Body. The Governing Body consists of distinguished scientists, health administrators and public men. The Union Minister of Health and Family Welfare is the President and the Secretary of the Ministry is the Vice-President of the Governing Body. The Governing Body is assisted and advised on scientific matters by a Scientific Policy Advisory Board which examines all proposals in relation to the scientific objects of the ICMR and reports on their feasibility.

A Task Force Approach is adopted by developing time-bound and specific goal-oriented research programmes, together with a regular monitoring and evaluation system, thus ensuring accountability of research. Peer review system has always been a feature of the working of ICMR. This has now been intensified and supplemented by further reviews by Task Forces, Streering Committees, Scientific Working Groups and Research Advisory Committees. Currently, nearly 95 Task Forces of the ICMR are functioning.

Bhabha Atomic Research Centre, Trombay



Nuclear Reactor Vessel for Rajasthan Atomic Research Power Plant at Kota

DEPARTMENT OF ATOMIC ENERGY

India, at the time of its independence, realised the importance and application of atomic energy in the national development. As a result, the Atomic Energy Commission (AEC) was set up as early as 1948, by a Parliamentary Act. The Commission is a national advisory body which is charged with the responsibility of developing an overall atomic energy programme including basic and applied research, training of personnel, applications in industrial use, survey and industrial use of minerals, etc., in the country. The executive agency for implementing the atomic energy programme is the Department of Atomic Energy which was set up in August, 1954 under the direct control of the Prime Minister. Earlier, the Commission's decisions were executed through the Department of Scientific Research and later through the Ministry of Natural Resources and Scientific Research.

During the last 25 years, the Department has built a nuclear technology base and a wide range of scientific and technical capabilities in the country. R&D efforts over the years have enabled the Department to evolve technologies for operating the entire fuel cycle -- from the exploration of uranium to the reprocessing of spent fuel and recycling of plutonium. There has been a significant spin-off from the nuclear programme and R&D efforts of the Department in the fields of space, defence, industry, agriculture and medicine.

Research and development work in the area of atomic energy is mainly carried out at Bhabha Atomic Research Centre (BARC) at Trombay near Bombay. BARC was set up as the Atomic Energy Establishment, Trombay in 1957, and renamed in 1967. It is a national centre for research and development and is the largest single scientific establishment in the country spearheading the national efforts in harnessing nuclear energy for peaceful purposes. Besides research in nuclear sciences, research groups and facilities have been organised in such diverse fields as chemical engineering, metallurgy, vacuum technology, reprocessing technology, fuel fabrication, waste management, radiochemistry, radiation medicine, biology, food technology, etc. Its facilities include four research reactors, namely CIRUS(40 MW), APSARA(1 MW), ZERLINA(a zero energy thermal reactor), and PURNIMA(a zero energy fast reactor), a 5.5 MeV Van de Graaff Accelerator. R 5, a 100 MW thermal reactor, is under construction. The Centre also has a uranium metal plant, a fuel element fabrication plant and a plutonium plant.

The setting up of its plutonium plant in early 1964 was hailed as a significant achievement in the nuclear fuel cycle. This was followed by the setting up of another reprocessing plant(PREFRE) at Tarapore in 1979 to reprocess the spent fuel. Trombay

plutonium plant is also being expanded. A third reprocessing plant to be located in Kalpakkam is in the final stage of approval. BARC has also been collaborating with BHEL for setting up an experimental coal-based magneto-hydro-dynamic plant at Tiruchirapalli. The Variable Energy Cyclotron at Calcutta was made available to number of research institutes and universities for scientific experiments. BARC has developed and has been producing a large number of isotopes for use in industry, such as for detecting microscopic cracks and other flaws in fabricated components, castings and pipelines and for use in diagnosis and treatment of various diseases.

A commercial radiation sterilisation plant at Trombay, called ISOMED, provides sterlisation service to the medical products industry in the country. The Radiation Medicine Centre at Bombay handles diagnostic and the therapeutic application of radio-isotopes. The Gauribidanur Seismic Station of BARC, set up in 1965 near Bangalore, helps in the detection and identification of underground nuclear explosion and also facilitates seismic research. A High Altitude Research Laboratory of BARC set up in 1963 at Srinagar provides facilities for high altitude research in the country. There is also a Nuclear Research Centre at Srinagar.

The BARC also conducts a country-wide personnel monitoring service and evaluating radiation exposure of workers in institutions using radiation sources, besides carrying out radiological protection surveys. With a view to achieving self-reliance in the development of trained scientific and technical personnel, the Department started a training school at BARC in August 1957. About 150 graduates in science/engineering are selected for one year training course every year. In addition, the Department also runs a nuclear training centre at RAPS, Kota for training of operation and maintenance personnel for the nuclear power stations.

BARC has also a modern scientific library in the country. The library holdings now stands at 664,000, including 520,000 technical reports, 17,600 patents and standards, etc. About 50 per cent of the total library holdings are computerised. It is also participating in the International Nuclear Information System (INIS), Vienna since 1970. The SDI services based on INIS tapes using IRIS - 80 computer at VEC, Calcutta is being provided to 450 individuals and scientific groups of the Department.

The Reactor Research Centre at Kalpakkam in Tamil Nadu of the Department undertakes R&D work in all aspects of fast breader reactor technology. The most important facility in this Centre will be the Fast Breeder Test Reactor, which is presently under construction. In addition to R&D carried out in the above institutions, institutions like Tata Institute of Fundamental Research, Bombay and Saha Institute of Nuclear Physics, Calcutta are engaged in research activities geared to achieve self reliance

in nuclear science and technology. The Tata Institute of Fundamental Research was founded in June 1945. It is a national centre for nuclear science and mathematics. The Saha Institute of Nuclear Physics was formally opened in January 1950 and its field of research includes all areas of nuclear physics. The Department has also under its control the Tata Memorial Centre which comprises two institutions: The Tata Memorial Hospital and the Cancer Research Institute. The Cancer Research Institute, being one of the foremost cancer treatment centres in the country, also conducts extensive basic and clinical research on cancer. The Tata Memorial Hospital is now a leading centre and a post-graduate university training centre in surgery, pathology, radiology, anaesthesiology, biochemistry, etc. The research institute offers courses leading to M.Sc. and Ph.D. in basic sciences.

The Department also supports R&D work in various disciplines related to atomic energy and provides project-linked financial assistance and fellowships to other academic institutions. The Department has constituted an advisory body, viz. the Board of Research in Nuclear Sciences, comprising eminent scientists and senior officers of the Department. It is assisted by 8 advisory committees in various fields. The Department offer training, fellowships, scientific visits, etc. to members of IAEA under its technical assistance programme.

In addition to R&D, the atomic energy programme of the Department covers a wide range of independent activities undertaken by its other units. Survey, processing and development work relating to uranium, thorium, beryllium, etc. is carried out by the Atomic Minerals Division, with its headquarters at Hyderabad. It has five regional branches in other parts of the country. The Indian Rare Earths Limited, functioning since 1950, extracts rare earths, minerals and thorium from the beach sands of South India. It operates a mineral sand industry in Manavalakurichi and Chavara and the rare earth industry at Alwaye. It also produces thorium products at Trombay. The Company is setting up Orissa Sands Complex (OSCOM) for enhancing production of rare earth minerals. During the next few years, the company proposes to set up a new uranium recovery plant, and a helium recovery plant. The R&D programmes of the company carried out in close collaboration with BARC, are diverse; it produces compounds of individual rare earths, zirconium chemicals, and zircon-based products. The Company plans to go in for large scale diversification in the field of separation of high value individual rare earth elements from mixed rare earths. The Uranium Corporation of India Limited, Jaduguda, set up in April 1967, is responsible for mining and processing of uranium ore in the country. It is currently producing uranium concentrate from the iron mines at Jaduguda. Its current R&D programme lays emphasis on recovery of nickel from

nickel-copper concentrates, and facilities on pilot plant scale are being augumented. Investigations are also continued on direct leaching of copper tailoring to ascertain the feasibility of improving the rate of recovery of uranium and improving the production of finer magnetite with higher magnetic content. A Nuclear Fuel Complex at Hyderabad fabricates fuel elements for nuclear power reactors. The Complex also prepares special materials needed for the electronics industry.

Manufacture of sophisticated electronic instruments and equipment for nuclear as well as non-nuclear uses, including commercial TV sets and computers, are undertaken at the Electronics Corporation of India Ltd., Hyderabad. This Corporation was set up in April 1967 as a spin-off from the BARC. The Company has identified controls, computers and communications as the major thrust areas of growth. It has executed several projects and introduced 64 new products range. Among the major products are ECIL computer systems, antennae, trans-receivers, programmable logic controllers etc. So far about 350 ECIL computer systems have been installed in Indian organisations

From the early days of the Department, considerable thought has been given to the potential of atomic energy in the context of the national power programme. India's nuclear power began with the commissioning of two units of 210 MWe capacity each of Tarapur Atomic Power Station in 1969. Two units of 220 MWe each going critical in December 1972 and April 1981 respectively at Rajasthan Atomic Power Station were added to bring the installed capacity to 860 MWe. The Power Project Engineering Division of the Department undertakes construction and operation of the nuclear power stations. Presently it is constructing Unit II of the Rajasthan Atomic Power Station, the Madras Atomic Power Station at Kalpakkam in Tamil Nadu and the Narora Atomic Power Station at Narora in U.P. The power reactors being constructed at present use heavy water as moderator. To produce this rare commodity within the country, a small plant is functioning at Nangal. Besides this plant, there are four heavy water plants at Vadodra, Kota, Talcher and Tuticorin.

DEPARTMENT OF ELECTRONICS

The Government of India recognised the key role of electronics in modern science and technology. In order to guide the growth of this vital sector in a balanced manner, the Government of India is taking keen interest since 1960's. As early as 1963, the Electronics Committee was appointed by the Government of India under the Chairmanship of Dr. H.J. Bhabha with a view to: (1) assessing the total requirements of the country

in respect of various items of electronics components and equipments, (ii) surveying the existing and potential sources of supply and to recommending how best these sources can be tapped and capacity expanded, and (iii) recommending measures for the planned development of electronics, so that the country as a whole may become self-sufficient in the field in the shortest possible time and in a most economical manner. There has been a steady growth in the electronics industry in India since Bhabha Committee submitted its recommendations in 1966. The Bhabha Committee reviewed the status of electronics industry and the prevailing technology to estimate the requirements of electronic equipment for the decade 1966-75 and made a number of recommendations. Government accepted all the recommendations made by the Bhabha Committee. For advising Government in the implementation of the recommendations of the Bhabha Committee, an Electronics Committee was appointed under the Chairmanship of Dr. Vikram A. Sarabhai in June 1966. The Committee has initiated a number of programmes. After a gap of a few years, the Government of India organised the National Conference on Electronics at Bombay in March 1970 with a view to discussing the various aspects of the electronics industry since the publication of the Bhabha Committee Report. A large number of Panels of Experts on different aspects of electronics industry were constituted by Government of India as a result of deliberations at the conference. After reviewing the progress of industry since the submission of the Bhabha Committee Report, the Panel of Experts constituted during the above National Conference emphasized that it was imperative to set up an organisation to review the entire field of electronics in view of fast changing technology and to recommend ways for achieving self-sufficiency in the shortest possible time and in the best possible manner.

Later the Government of India constituted Department of Electronics (DoE) with effect from 26 June 1970. The Department of Electronics, as defined in the Allocation of Business Rules of the Constitution, is charged with the responsibility of: (a) Development of electronics and co-ordination among the various users, (b) All matters relating to the personnel under the control of the Department, (c) Co-ordination of requirements relating to electronic processing equipment (computers) and (d) All matters concerning computer based information technology and the processing including hardware and software, standarization of procedures and matters relevant to international bodies such as IFIP, IST, TCC.

Subsequently in February 1971, Government constituted the Electronics Commission under the chairmanship of Professor M.G.K. Menon. The Electronics Commission has been charged with full responsibility to review the entire field of electronics with

regard to research, development and industrial operations, with full authority to formulate policies in this field and to direct implementation, on sound technical and economic principles, of all measures, both promotional and regulatory, that are necessary for the country to attain self-reliance. After the setting of this Commission, the Department of Electronics became an executive arm of Electronics Commission for implementing the various policies and decisions arrived at it from time to time. Recognising the importance of accurate and timely information, for macro and microlevel planning, and for critical in-depth techno-economic analysis, the Electronics Commission set up an Information, Analysis and Planning Group (IPAG), with the mandate to provide information required by the Electronics Commission for its decision-making, as well as to disseminate information to laboratories, industries, enterprises and all concerned with the growth of electronics industry.

As a follow-up of the recommendations of the National Seminar on R&D Electronics Policy (New Delhi in January 1973), the Electronics Commission also set up a Technology Development Council (TDC) in October 1973 to assist and advise the Electronics Commission in fulfilment of its manifold tasks in electronics R&D. TDC is a advisory body and its principal functions are to assist the Department of Electronics/Electronics Commission in: (i) identification of areas requiring intensive R&D efforts in the field of electronics, (ii) assigning relative priorities, (iii) ensuring the transfer of know-how generated through R&D to production, and (iv) identification of areas requiring import of know-how at the R&D or production levels to conform to financial and time targets laid down for the growth of the industry. The Council has set up six Working Groups on different sectors of electronics in areas of: (i) materials and components, (ii) consumer electronics, (iii) computers, control and industrial electronics, (iv) radars, sonars and navigational Aids, (v) communication and broadcasting, and (vi) electro-mechanical components and equipment. In order to facilitate a regular exchange of ideas and mutually beneficial interactions among all concerned agencies in Government and outside, the Electronics Commission set up a National Advisory Committee on Electronics (NACE) in September 1973, under the chairmanship of Prof. M.G.K. Menon. NACE acts as a broad-based forum for discussion on all aspects relating to the growth and development of electronics industry. It consists of 80 members drawn from government department, associations of industry and trade, academic institutions, research laboratories, public sector undertakings, and small scale sector. The committee is responsible for discussing problems of general interest relating to R&D, industrial licensing, industrial operations, education, training and manpower, role of various sectors, etc. and for providing a

broad-based set of views to the Electronics Commission and the Department of Electronics on specific problems which may be brought to the notice of the committee from time to time.

In January 1974 the National Radar Council (NRC) was set up in the Department of Electronics by the Government of India to ensure proper co-ordination of the planning and R&D activities in the field of radars and sonars and to meet the requirements in the defence and civil sectors in an integrated manner, on the basis of maximum self-reliance.

The Department of Electronics has supported Regional Computer Centres at Calcutta and Chandigarh. The centres are autonomous non-profit societies under the Societies Registration Act of the respective States. They provide regional facilities to meet the computing requirements of the different regions and to promote computer awareness in all the sectors whether they be government, industry, education or commerce. Also the centres are expected to make substantial contributions to the computer manpower development.

Towards the end of 1974, a National Centre for Software Development and Computing Techniques (NCSDCT) was set up by Government of India with the assistance to the extent of Rs. 2.2 crores by UNDP. The basic objective of NCSDCT is to contribute to the growth of the computing technology and computational practices in India as a national resource. The centre is located in and managed by the TIFR. Considering the necessity for close co-ordination between NCSDCT and other National/Regional Computer Centres, it was decided that the NCSDCT should be transferred to the Department of Electronics. The facilities of the centre include a large duel processor computer system DEC 1077; the centre also operates an interactive graphic facility.

The Department of Electronics promotes the setting up of infrastructural support facilities for giving thrust to the appropriate growth of electronics industry with particular emphasis on standardisation, quality improvement, productivity improvement, tooling design centres etc. Under this programme, a countrywide network of integrated testing and calibration facilities have been planned. A three-tier echelon structure with Electronic Test and Development Centres (ETDCs) working as per Echelon-III level, Electronic Regional Test Laboratories (ERTLs) working as per Echelon-II level and primary calibration facility at NPL operating as per Echelon-I level, has been in operation. Under this programme, 16 ETDC and 4 ERTL have been established so far. The total programme is being monitored by an apex body - Advisory Committee for Regional and State Test and Development Centres (ACTC). Also, in order to bridge the gap between training imparted in the academic institutions and the competence required for the production environment, the Centre for Electronics Design

Technology was established in 1974 at Indian Institute of Science, Bangalore with co-operation and support from Swiss Federal Institute of Technology and Electronics Commission. With the success of this centre, the Department of Electronics decided to set up three more centres during the Plan period 1980-85 in the northern, eastern and western regions.

The Department of Electronics has also under its control three public sector units. The Computer Maintenance Corporation, New Delhi set up in 1975, provides a complete range of computer support service within the country. Its services include feasibility studies, site consultancy and preparation, installation and commissioning of computer systems, providing warranty support for them, computer centre services, systems consultancy, software development systems, systems integration services, customer education and training, and continuous research and development. The Electronics Trade and Technology Development Corporation, New Delhi set up in 1974, has the objective of expanding foreign trade in electronics and undertaking development of technology in key areas with particular emphasis on expanding exports. Also, a semiconductor complex in Chandigarh functions under the Department.

DEPARTMENT OF ENVIRONMENT

The concept of integrating environmental consideration into the process of planning for economic development was for the first time explicitly articulated in the Fourth Five Year Plan (1969-74). In 1972, the National Committee on Environmental Planning and Coordination (NCEPC) was set up under Department of Science and Technology to promote research on environmental problems. Later, a Man and Biosphere and an Environmental Research Committee were also set up - the former to look into ecosystems, conservation and natural ecosytem, and the latter to look into environmental aspects of human settlement, pollution, rural environment and other related areas. A large number of research and development projects have been funded under these committees.

A high level Committee headed by the Deputy Chairman, Planning Commission, was constituted in February 1980 to recommend the legislative measures for ensuring environmental protection. One of the recommendations of the Committee, which submitted its report in September 1980, was for setting up a Department of Environment (DoEn). In pursuance, the Government of India set up the Department of Environment which came into existance on 1 November 1980 under the direct control of the Prime Minister's Secretariat. The Department of Environment is

the focal point in the administrative structure of the Government for planning, promotion and co-ordination of environmental programmes. Formulation of environmental policy guidelines in different sectors; environmental appraisal of development projects; promotion of environmental research; eco-development activities; environmental information, education and awareness; and international cooperation in environmental matters are among the major functions of the Department. The Botanical Survey of India (BSI) and Zoological Survey of India (ZSI) are the major agencies of the Department for investigations on natural resources. The National Museum on Natural History (NMNH), which also comes under the Department, helps in mass education and awareness on environmental issues. The executive responsibilities for enforcement of acts on prevention and control of water and air pollution as also in respect of the Water Cess Act are carried out by the Central Board for the Prevention and Control of Water Pollution (CBPCWP) which is a statutory authority attached to this Department with effect from January 1982.

On policies and priorities, the Department is advised by the National Committee on Environmental Planning (NCEP) and other expert bodies. The earlier committee, first constituted in 1972 as NCEPC, advises the Department on policies and priorities. The Committee was reconstituted in March 1981. It has a wide spectrum of interests, disciplines and expertise drawn from governmental departments, and academic and research institutions. The other expert bodies set up by the Department include Working Groups for co-ordinated research programme in the Western Ghats, the Himalayan Region and the Ganga Basin.

Promotion of research related to environment and support for the building up of facilities and infrastructure in the country is one of the major activities of the Department of Environment. For this purpose, the Department has constituted the Man and the Biosphere Committee (MAB) and the Environment Research Committee (ERC). The MAB and ERC make recommendations in priority areas for environmental research besides scrutinising research proposals received from institutions throughout the country, evaluating the process of each project and recmmending suitable means for implementing research results.

The Eco-Development Programme of the Department addresses itself to the following tasks: (a) restoration of degraded eco-systems; (b) arresting further damage to eco-systems; and (c) evolving and promoting a development strategy which is in conformity with environmental consideration. The Eco-Development Board is a high level advisory body which was set up on 18 August 1981 to provide overall guidance to the eco-development programmes of the department.

The work relating to wildlife, which was with the Forestry Division in the Department of Agriculture and Co-operation, was transferred to the Department of Environment in September 1982. In this programme, the Department is assisted by Indian Board of Wildlife. The Department has also under the control the Delhi Zoological Park, which is assisted in its work by an advisory committee. Being the only Zoological Park in the country, the status of the park was enhanced to National Zoological Park by Government of India in 1982.

In the area of environmental monitoring, the Department proposes to set up a National Environmental Monitoring Organisation (NEMO).

The Water (Prevention and Control of Pollution) Act, 1974 became effective from 23 March 1974. Consequently, the Central Board for the Prevention and Control of Water Pollution (CBPCWP) was constituted in September 1974 for the purpose of implementing the provisions of the Water Act. The State Boards have since been constituted. The Air (Prevention and Control of Pollution) Act, 1981 came into force on the 16 May 1981. The Central Board for the Prevention and Control of Water Pollution also functions as the Central Board for the Prevention and Control of Air Pollution (CBPCAP) under this Act. Similarly, all the existing State Boards for the prevention and control of water pollution also function as the State Boards for the prevention and control of air pollution.

DEPARTMENT OF OCEAN DEVELOPMENT

In order to plan, coordinate and develop indigenous capability in oceanographic research in the country, Goverment of India set up an Ocean Science and Technology Agency (OSTA) in Department of Science and Technology in 1976. A Governing Board and a Standing Committee were appointed to guide the activities of this Agency. The Prime Minister was the Chairman of the Governing Board. A separate Marine Research and Development Fund was set up under OSTA to support R&D in this area.

The Department of Ocean Development (DOD) started functioning in July 1981 under the Cabinet Secretariat and from March 1982 as a separate Department under the Minister of State. The various activites to be dealt by DOD as notified are:

1. Matters relating to the ocean and not specifically allocated to any Ministry/Department.
2. Policies including co-ordination, security, regulatory measures and development relating to the ocean, covering;
   - i) research (including fundamental research) and the development of uses relatable thereto;
   - ii) technology development;

Dredge ready to be lowered for collection of seabed samples

RV Gaveshani, *the first Indian Oceanographic Research Vessel. The vessel first successfully collected Polymetallic Nodules from the Arabian Sea in January 1981. The vessel was latter deployed for the Surveys for Polymetallic Nodules in the Central Indian Ocean*

Assembled boomerang grab being deployed

Members of the Indian Scientific Expedition Camping on the Ice-Bound Antartica after Landing there on January 9, 1982

iii) surveys to map and locate the avaliability of non-living and living resources;
iv) preservation, conservation and protection;
v) development of appropriate skills and manpower;
vi) collaboration including technical collaboration ; and
vii) laws related to the above.

The Department deals with new and emerging programmes of ocean development both at the national and international levels.

The Department had supported either fully or partially many research programmes. The two major programmes supported in full are the Antarctic Research and the Exploration of Polymetallic Nodules in the Indian Ocean. Under the Antarctic Research Programme, the Department has organised two Scientific Expeditions to the South Indian Ocean and Antarctica during 1981-82 and 1982-83, and the next expedition is under way. The Department has proposed to set up a Manned Station at Antarctica by 1985-86 to make year-round continuous scientific observations.

DEPARTMENT OF SCIENCE AND TECHNOLOGY

The Department of Science and Technology was established in 1970 with the principal responsibilities of (i) promoting new areas of science and technology; (ii) undertaking or financially sponsoring scientific and technological surveys, research, design and development; (iii) supporting national research institutions and scientific bodies; (iv) co-ordinating all activities related to international S&T collaboration except in specific areas asigned to other agencies; (v) dealing with promotion of and support to indigenous technology; (vi) dissemination of scientific and technical information; (vii) co-ordinating multi-institutional inter-disciplinary activities in areas of science and technology; and (viii) providing sectoral support to the Science Advisory Committee to the Cabinet. A brief description of the activities can be summarized under the following areas.

A principal activity of the Department has been the co-ordination and promotion of S&T activities in several frontier and newely emerging areas of science and technology. The Science and Engineering Research Council (SERC), set up in the Department, identifies and supports frontline research in various fields. A high level committee of scientists under the Department scrutinizes proposals under the General Research Fund (GRF). An important element of S&T promotion, which relates to strengthening of infrastructural facilities which are required by the large scientific community in the country, was also taken into account by creating specialised Regional Sophisticated Instrument Centres (RSICs). So far 7 such centres have been set up in

different parts of the country. To encourage S&T activities at the State level, the scheme for providing assistance for the development of State Councils for Science and Technology was initiated during 1981-82. Sixteen State Councils on Science and technology and/or State Departments on Science and Technology were functioning by the end of 1982-1983. In addition, 22 States and 8 Union Territories have also formulated their S&T Plans.

Increasing attention has been paid to the promotion and support of indigenous technology through measures such as: registration of R&D units set up within the industry; appropriate fiscal incentives for expenditure incurred on scientific research and for financial contribution to scientific research institutions; weighted tax benefit for sponsoring and carrying out research in R&D units on programmes approved by DST; and investment allowences at enhanced rates on investments made on commercialising indigenous technology. So far 836 such units have been registered.

The indigenously developed technologies are mostly licensed through the National Research Development corporation of India (NRDC), New Delhi, a public sector undertaking. It has been engaged in promoting the development, commercialisation and transfer of technology in the country during the last three decades. NRDC promotes the utilization of such technologies through equity participation, by providing financial support for development projects, assisting in horizontal transfer of technology, and support for export of indigenous technologies, etc. The Central Electronics Limited (CEL), is yet another public sector undertaking set up in June 1974 under the administrative purview of DST with the object of commercialising know-how developed in national laboratories and public institutes in the area of electronic components, instruments and systems. It has made advances in photovoltaic systems and a wide range of products on ceramics have also been developed indigenously.

In the area of information, a major programme of DST is the National Information System for Science and Technology (NISSAT) established in 1974. In addition to strengthening the activities of the existing Information Centres on Leather, Drugs, Machine Tools and Foods, one more information centre namely, the National Information Centre on Crystallography, has been brought under NISSAT support.

The National Biotechnology Board (NBTB), recommended by the Science Advisory Committee to the Cabinet (SACC), was set up under DST by a resolution of Government on 18 January 1982. The main objective of NBTB is to evolve a national co-ordinated, short and long-term plan of research and development, utilization of known technologies, strengthening the existing infrastructure and wherever necessary, setting up centres in the newly developing thrust area of biotechnology.

While dealing with the question of employment and manpower planning of S&T personnel, SACC had suggested various measures, one being the creation of a National Science and Technology Entrepreneurship Development Board; this was set up by a resolution of Government on 18 January 1982. The main objectives of the Board are to deal with the problem of unemployment and inappropriate employment among qualified S&T personnel; to ensure institutional, single-window mechanism at the central level for entrepreneurs desirous of setting up production ventures; and to promote opportunities for gainful self-employment for them and to develop entrepreneurship.

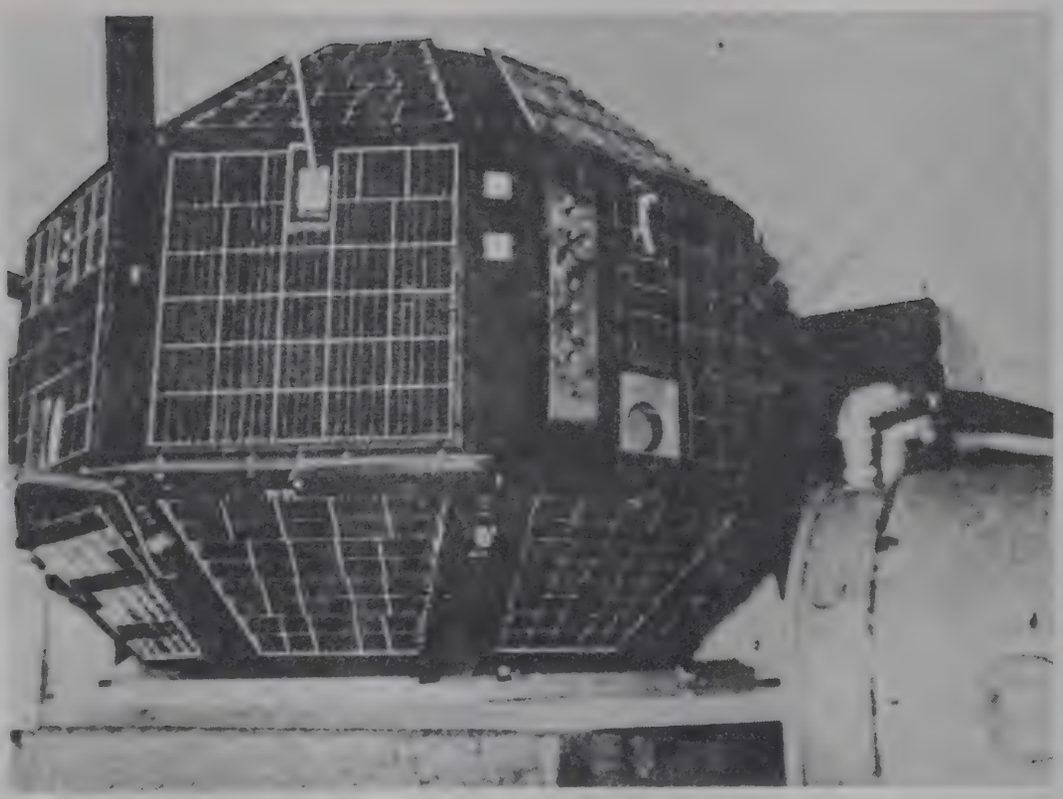
The Survey of India and the National Atlas Thematic and Mapping Organisation, under DST, are concerned with the preparation of several maps of the country, needed for survey support to Defence Forces and other purposes and preparing a National Atlas of India. The Survey of India has also undertaken several nationally important development surveys and mapping projects related to the coal fields, irrigation, power generation, communication and flood control, water supply, forestry, cantonment areas, landing and approach charts of the Indian Air Force, tidal observations and command and canal area development. Several programmes on prototype fabrication and training of scientists have also been taken.

A few autonomous scientific institutions in the country are fully or partially supported by the DST through regular annual grants. Most of these institutions had been set up - some of them several decades ago - as societies under the Societies Registration Act and continue to have the same formal status. There are:

1. Birbal Sahni Institute of Palaebotany, Lucknow
2. Bose Institute, Calcutta
3. The Indian Association for the Cultivation of Science (IACS), Calcutta
4. Maharashtra Association for the Cultivation of Science (MACS), Pune
5. National Institute of Immunology (NII), New Delhi
6. Padmaja Naidu Himalayan Zoological Park (PNHZP), Darjeeling
7. Raman Research Institute, Bangalore
8. Sree Chitra Tirunal Institute for Medical Science and Technology, Trivandrum
9. Wadia Institute of Himalayan Geology, Dehra Dun.

DEPARTMENT OF SPACE

India's activities in space can perhaps be traced to the first quarter of the nineteenth century when the Colaba Observatory was set up in 1823 at Bombay followed by the creation of the India



Aryabhata going through the Vibration Test

Thumba Rocket Launching Station

Meteorological Department (IMD) in 1875. About a century later, ionospheric studies began in Calcutta University (1926). Research in the field of physics of the upper atmosphere and astrophysics began in the begining of the twentieth century in India and was confined to individuals largely in centres of higher learning such as the universities. The resultant increase in funds and manpower and facilities focussed scientific activities towards large scale efforts in areas such as cosmic rays and the physics of the upper atmosphere. These activities then evolved in a very natural way to encompass studies of elementary particles and nuclear physics at the Tata Institute of Fundamental Research (TIFR), Bombay, and of the earth's environment, interplanetary space, solar physics and astronomy at the Physical Research Laboratory (PRL) at Ahmedabad and later at the National Physical Laboratory (NPL) at Delhi.

Against this background, the Department of Atomic Energy (DAE), which in 1961 had been entrusted by the Government of India with the subject of the peaceful uses of outer space, set up the Indian National Committee for Space Research (INCOSPAR) in 1962 to advise and help organise India's space programme. An important step was taken in 1963 by the establishment of India's first rocket launching facility TERL at Thumba, with international co-operation. Soon after TERL came into existance, Indian space scientists started work on developing their own sounding rockets and scientific payloads. In view of the vital role of scientific communication and need for trained manpower in this field, an Experimental Satellite Communication Earth Station (ESCES) was set up in 1967 in Ahmedabad with support from the UNDP and ITU. The expansion of these activities resulted in organizational changes. The Indian Space Research Organisation (ISRO) was set up in 1969 by the Department of Atomic Energy to deal with matters relating to space.

Realising the importance and application of space research, the Government of India set up a Space Commission and Department of Space in 1972. INCOSPAR later become one of the several Committees of the Indian National Science Academy. The Space Commission is responsible for promoting the development and application of space science and technology for identified national socio-economic tasks. The responsibilities of the Commission include the framing of policy, formulation of the budget of the Department of Space and implementation of Government's policy in all matters concerning outer space. The Department of Space (DoS) is responsible for the execution of entire space activities in the country. All other agencies connected with space research were brought later under the executive control of the Department of Space and Indian Space Research Organisation, the National Remote Sensing Agency, etc.

The Department of Space and the Space Commission work under the direct control of the Prime Minister. The Chairman of the Space Commission is also Secretary to the Government in the Department of Space.

The Department of Space executes its functions mainly through the Indian Space Research Organisation (ISRO) in space sciences, technology and applications. The DoS and the ISRO Headquarters provide overall guidance and direction to the technical, scientific and administrative functions of the ISRO Centres. The ISRO Centres are: the Space applications Centre (SAC) in Ahmedabad, the ISRO Satellite Centre (ISAC) and Auxiliary Propulsion System Unit (APSU) in Bangalore, the Vikram Sarabhai Space Centre (VSSC) in Trivandrum, and the SHAR Centre at Sriharikota in Trivandrum. The Civil Engineering Division carries out work relating to civil work. ISRO is responsible for planning, programming, execution and technical management in the areas of space technology and applications. The Physical Research Laboratory (PLR) at Ahmedabad and the National Remote Sensing Agency (NRSA) at Secunderabad are institutions mainly supported by the Department to conduct research programmes in space and related sciences.

The Department of Space set up an Advisory Committee for Space Sciences (ADCOS) in 1980 which aims at exploring and encouraging Indian scientists working at different organisations in the country, in the conduct of quality research in the space sciences and related areas.

Since 1976, ISRO has been supporting research and development projects in the universities under its RESPOND programme. ISRO support mainly relates to basic research and development aspects of space science, technology and applications relevant to the Indian Space Programme. In addition to providing financial grant for appointment of research and support staff, purchase of special equipment and other operational expenses, ISRO's own facilities are made available to the principal investigator, if necessary. So far 161 R&D projects have been supported, of which 70 projects have been completed.

MINISTRY OF DEFENCE

Subject to the overall responsibility of the Cabinet and under its guidance, the Ministry of Defence discharges its responsibilities in regard to the defence of the country. The Ministry of Defence is organised into four different Departments namely: (i) Department of Defence Research and Development, (ii) Department of Defence Production, (iii) Department of Defence, and (iv) Department of Defence Supplies.

DEPARTMENT OF DEFENCE RESEARCH AND DEVELOPMENT

This Department is headed by the Scientific Advisor to the Defence Minister, who is Secretary to Government and renders technical advice on specific aspects of military operations, equipment and logistics and formulates research, design and development plans with regard to the needs of the three Services. This Department is administratively responsible for the activities of the Defence Research and Development Organisation.

Prior to independence, the technical requirement of the Defence Forces were being provided only to a limited extent through a number of Technical Development Establishments (TDEs). In 1948 the Defence Science Organisation was set up, as it was realised that for a independent India it was not appropriate to depend upon a long-term basis on imports of all that is required by the Defence Forces of the country.

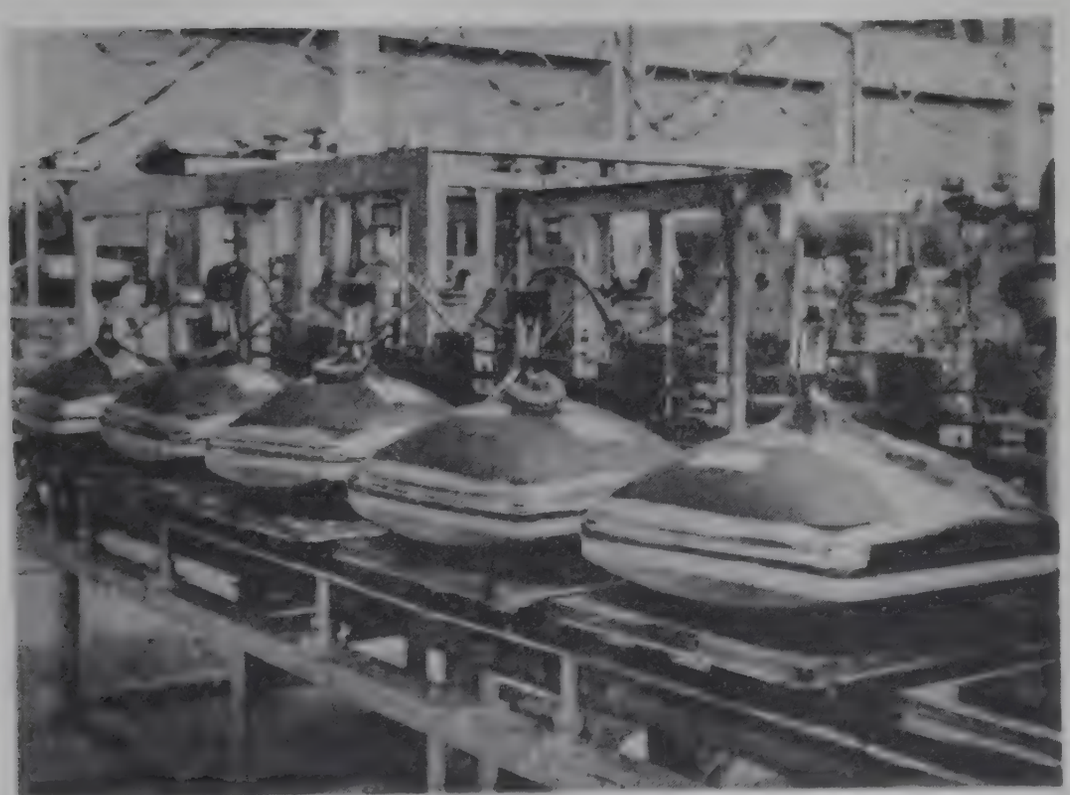
In 1958, some of the TDEs were amalgamated with the Defence Science Organisation, resulting in the establishment of the Defence Research & Development Organisation (DRDO), which was then assigned the following charter of duties:

a) To design and develop weapons using the latest discoveries in science and to carry out applied research to solve the problems of the services;
b) To design and develop weapons and equipment based on the operational requirements defined by the services and to help in their indegenous production;
c) To render scientific advice to the Service Headquarters;
d) To evaluate and conduct trials of new weapons and equipment and those designed and developed in the country, and
e) To render technical guidance to trade for development of new equipment.

The Defence Research & Development Organisation has built up the necessary infrastructure and competence in a variety of scientific and technological disciplines of relevance to Defence. Some of the important areas of research and development are: arnaments, electronics, rockets, and missiles, aeronautics, naval science and technology, engineering, vehicles and materials technology. To carry out design and development of sophisticated and complex weapon systems involving the technologies mentioned above DRDO has a network of 37 well equipped labcratories/establishments distributed all over the country.

The R&D activities of DRDO can be broadly classified into two distinct categories. The projects which are based on the specific qualitative requirements projected by the Services are called "Staff Projects". Simultaneously, efforts are continually in progress to build up expertise in the contemporary and futuristics technologies of relevance to defence. As distinguished from Staff Projects, these are called "Competence Build-up Projects".

Dom. Dia Steerable Antenna for Overseas Communications Service, Dehradun Manufactured by ECIL, Hyderabad



Bharat Electronics Limited, Bangalore

DEPARTMENT OF DEFENCE PRODUCTION

The Department of Defence Production was set up in 1962 with the main aim of achieving the twin objectives of self-reliance and self-sufficiency in the field of defence needs. It has been the effort of the Department to encourage the growth of ancilliary industry and to maintain a very high standard of quality control and reliability. Efforts are also made regarding standardisation of equipment with a view to reducing the inventory with the Defence Forces.

The two main streams of production of different equipment and stores are the departmental ordinance factories and nine defence public sector undertakings. In addition to indigenisation, continuous efforts are made towards modernisation of the production apparatus and updating of the S&T base. Apart from the production establishments referred to above, the Department is also responsible for the Directorate General of Inspection, Directorate of Technical Development and Production (Air), Directorate of Planning and Coordination and Directorate of Standardisation.

PUBLIC SECTOR UNDERTAKINGS

The nine public sector undertakings under the administrative control of the Department of Defence Production are Hindustan Aeronautics Limited (HAL), Bharat Electronics Limited (BEL), Bharat Earth Movers Limited (BEML), Mazagon Dock Limited (MDL), Garden Reach Ship Builders and Engineers Limited (GRS&E), Goa Shipyard Limited (GSL), Praga Tools Limited (PTL), Bharat Dynamics Limited (BDL) and Mishra Dhatu Nigam Limited (MDNL).

MINISTRY OF ENERGY

The Ministry of Energy was constituted in 1974 and comprised Department of Coal and Department of Power. It was reconstituted with effect from 11 September 1982 with the expansion of the Ministry, by the addition of two more Departments, i.e. Department of Petroleum and Department of Non-Conventional Sources of Energy. Prior to their inclusion in the Ministry of Energy, these Departments were part of the erstwhile Ministry of Petroleum, Chemicals and Fertilizers and Department of Science and Technology.

The Ministry of Energy is responsible for formulation and implementation of the general policy in the field of energy and for the development of different energy sources. The responsibility of

the development of petroleum, coal, power and non-conventional sources of energy lies with the specific Departments of the Ministry of Energy dealing with these programmes. A Cabinet Committee on Energy supported by the Committee of Secretaries monitors the implementation of the National Energy Policy and decides on important issues relating to energy. The Energy Research Committee of the Department provides an integrated approach to the R&D activities in the energy sector.

DEPARTMENT OF POWER

The Department of Power is responsible for the development of electric energy and policy relating to generation, transmission, distribution and conservation. Besides this, the Department also coordinates matters relating to Energy Policy. The Department is responsible for legislation on electricity and administers the Electricity (Supply Act, 1948 and Indian Electricity Act, 1910). The Central Electricity Authority constituted under the Electricity Supply Act; advises the Department of Power on matters concerning power.

The Department of Power controls:(i) research and training organisations, viz. Central Power Research Institute (CPRI), and Power Engineers Training Society (PETS); (ii) central sector power corporations, viz. National Thermal Power Corporation (NTPC), National Hydroelectric Power Corporation (NHPC), North-Eastern Electric Power Corporation (NEEPCO), Rural Electrification Corporation (REC), and National Project Construction Corporation (NPCC); (iii) statutory bodies, viz. Damodar Valley Corporation (DVC), and Bhakra Beas Management Board (BBMB); and (iv) construction agencies, like Beas Construction Board (BCB).

The Central Electricity Authority's main functions are: promoting research in electricity; rendering advice and consultancy in different areas of electricity; formulating of short-term and perspective power development, etc. Its consultancy services include design and engineering of hydro and thermal power projects and power systems in India and abroad. During 1982-83, consultancy services were undertaken for 36 hydro-electric projects in India and 8 hydro-electric projects abroad, mainly in Afganistan, Burma and Bhutan. Complete project design and engineering consultancy services were also rendered to 9 thermal power projects in India. Consultancy services were also rendered to a number of State Electricity Boards, Electricity Departments and power projects in the design and engineering of transmission line towers, sub-stations, transmission lines etc.

DEPARTMENT OF COAL

The Department of Coal in the Ministry of Energy is

responsible for exploration and development of coking and non-coking coal and lignite; all matters pertaining to production, supply, distribution and prices of coal; low temperature carbonisation of coal and production of synthetic oil from coal; and public sector enterprises dealing with coal and lignite.

The Department has under its control Neyveli Lignite Corporation and Coal India Limited and its subsdiaries, viz. Central Coalfield Limited, Western Coalfields Limited, Bharat Coking Coal Limited, Eastern Coalfields Limited, and Central Mine Planning and Design Institute Limited.

A standing committee on science and technology, set up in 1978 in the Department of Coal, scrutinises and recommends the R&D projects for implementation and also for the periodical review of the progress. The Department has also instituted a Coal Scientist Award for meritorius research either in application oriented research or development research in the field of science and technology including energy development.

The Coal India Ltd., a holding company set up in 1975, is mainly responsible to set overall corporate objectives, approve and monitor performance of the subsidiaries companies for achievement of these objectives, especially in the field of long-term planning, conservation, R&D, etc. Central Mine Planning and Design Institute Ltd. is an independent consultative body whose function is to render expert advice on mineral exploration, and planning and design of mining, mineral beneficiation and coal utilisation projects. It is equipped to take consultancy jobs in these field both within the country and abroad. The Institute has four regional institutes located in Asansol, Dhanbad, Ranchi and Nagpur besides its head office in Ranchi.

DEPARTMENT OF PETROLEUM

The Department of Petroleum deals with the exploration and production of oil and natural gas, refining and distribution of petroleum products and petro-chemical products.

A Scientific Advisory Committee for the Department of Petroleum consisting of eminent scientists and technologists from universities and research institutes advises the Minister of Petroleum on policies relating to science and technology and measures to implement them to ensure the optimum processing of hydrocarbon raw materials for use as fuels and chemicals. An Advisory Committee on Environmental Planning and Coordination advise the Minister on all aspects of environmental planning for schemes and programmes of the Department. A Scientific Advisory Committee for Geosciences advise the Minister on science and technology policies relating to geoscience with special refernce to oil exploration. The Department has under its control 15 public sector undertakings, 3 subsidiaries and 4 other organisations.

The Oil and Natural Gas Commission (ONGC), set up in 1956, is responsible for the exploration and production of oil in both onshore and offshore areas of the country. A significant achievement of the ONGC has been the development of Bomaby High.

The R&D work of the ONGC is looked after by its constituent research institutes, namely the Keshov Dev Malaviya Institute of Petroleum Exploration (KDMIPE), Dehra Dun, the Institute of Drilling Technology, Dehra Dun and the Institute of Reservoir Studies (IRS), Ahmedabad. These institutes have achieved high technical competence.

There are 12 refineries currently working under the Department of Petroleum. These are India Oil Corporation Ltd., at Gauhati, Barauni, Koyali, Haldia, Mathura and Digboi; Madras Oil Refineries Ltd. at Madras; Cochin Refineries Ltd. at Cochin; Bharat Petroleum Corporation Ltd. at Bombay and Vizag; and Refinery and Petro-chemicals Ltd. at Bongaigaon.

The Indian Oil Corporation, set up on 1 September 1964, has established an R&D Centre at Faridabad (Harayana).

Indian Petrochemical Corporation Limited (IPCL), set up at Jawaharnagar in Gujarat in 1969 as a wholly owned company of the Government of India, has established a large integrated petrochemical complex near Vadodra.The Corporation has a well equipped Research and Development Centre in its complex. An Application Centre for plastics and rubber has also been established to assist the processors and investors by educating them on the numerous applications of various materials.

Petrofils Corporations Limited, a cooperative society registered in 1974, has been set up for production of polyester filament yarn with an initial capacity of 3500 tonnes per annum. Engineers India Limited (EIL) was incorporated in 1965 and became a wholly state undertaking in 1967. To intensify R&D efforts, EIL is in the process of setting up a research centre. The Company through the R&D Centre endeavours to develop new/improved capabilities for equipment design and energy conservation.

The Central Institute of Plastics Engineering and Tools (CIPET), Madras was set up in 1968 by the Government of India with assistance from UNDP for imparting specialised training and assistance to the development and growth of plastics industry. The main areas of work of the institute are training, development, testing, standardization and quality control and consultancy and other services. The Government has sanctioned the establishment of an extension training centre of CIPET in Ahmedabad.

DEPARTMENT OF NON-CONVENTIONAL ENERGY SOURCES

The Department, established on 6 September 1982 in the Ministry of Energy, looks after: (i) research and development of biogas and programmes relating to biogas units, and (ii) Commission for Additional Sources of Energy (CASE).

The CASE, set up on 12 March 1982 has the following functions:

(a) Formulating policies and programmes for development of new and renewable sources of energy;

(b) Coordinating and intensifying research and development activities in new and renewable sources of energy;

(c) ensuring the implementation of Government's policies in regard to all matters concerning new and renewable sources of energy; and

(d) preparing a budget for the Commission.

MINISTRY OF HEALTH AND FAMILY WELFARE

In the area of medical education, research and training, there are five regulatory bodies, namely Medical Council of India, National Academy of Medical Science, Dental Council of India, Indian Nursing Council, and Pharmacy Council of India. The Medical Council of India is a statutory body established under the Indian Medical Council Act, 1956, and is responsible for the maintenance of standards of medical education in the country. The Council is also entrusted with the maintenance of the "Indian Medical Register". The prestigious Dr.B.C.Roy National Award, the Hari Om Ashram Alembic Research Award, etc. are awarded by the Council. The National Academy of Medical Sciences, established in 1961 as a registered Society in pursuance of a resolution passed the Central Council of Health, is a premier body of learned medical scientists in India with 394 fellows and 726 members. The Academy is entrusted with the task of imparting continuing medical education programme for physicians, practitioners, consultants, postgraduate students and researchers in medical field in the country, with a view to updating their knowledge in their fields of specialisation. The Dental Council of India and Indian Nursing Council and Pharmacy Council of India, set up during 1947-78, are responsible for regulation of dental, nursing and pharmacy education in the country.

There are four premier research and training institutions attached to the Ministry. The All India Institute of Medical Sciences, New Delhi, a statutory and autonomous body, was established in 1956 by an Act of Parliament. It has been declared as an institution of national importance.

Jawaharlal Nehru Institute of Post-Graduate Medical Education and Research, Pondicherry (JIPMER) is administered by the Ministry of Health and Family Welfare through DGHS. The institute started in November 1956 as medical college, and 1965, it was upgraded as a Regional Post-Graduate Medical Education and Research Centre. The JIPMER Hospital and ancilliary units, started functioning from April 1966. The institute offers number of postgraduate and Ph.D. courses and programmes.

The V.P.Chest Institute is another premier institute which is financed by the Ministry of Health and is administered by a Governing Body constituted by the Executive Council, University of Delhi. The institute conducts applied and basic research on major chest ailments including lung diseases of infectious and non-infectious origin.

The National Institute of Communicable Diseases, Delhi, established in July 1963, is engaged in fundamental and applied research in the area of communicable diseases, provides services in the mater of health programmes, organises training programmes and advises the Government in matters relating to health planning in respect of communicable diseases.

The Central Research Institute, Kasauli (estd.1965) is premier research institute in the field of research on medical and public health problems, production and quality control of immunobiologicals and for its teaching and training programmes. The institute is the biggest and most comprehensive producer of immunobiologicals. It is also recognised as a national testing laboratary for testing of immunobiologicals for vaccines produced at other laboratories in India or imported from abroad. It also prepares national preference standards caliberated against international standards.

The National Institute of Mental Health and Neuro Sciences, Bangalore, established in December 1974 as an autonomous institution, is engaged in rendering services, training and research functions in the field of mental health and neurosciences. It also offers a number of postgraduate courses.

The All India Institute of Hygiene and Public Health was established in Calcutta on 30 December 1932. It is the oldest school of public health devoted to postgraduate teaching and research in various disciplines of health and related sciences, both in India and in the South-East Asian Region.

The Pasteur Institute of India, Coonoor, Nilgiris is engaged in the production of antirabies vaccine and DTP vaccines. It carries out research in rabies, influenza and other respiratory virus infections, diseases caused by intestinal viruses like polio, and bacterial diseases like enteric fevers.

The Central Bureau of Health Intelligence in the DGHS collects, analysis and disseminates information on health conditions in the country as a whole.

The Central Health Education Bureau (CHEB),established in 1956, coordinates health education activities of the national and other health programmes and provides guidance for the State Health Education Bureaus. The National Medical Library,New Delhi is a national focal point for health science libraries in the country and provides services to users.

In the Sixth Plan, considerable resources have been allocated under the Central Sector for the development of Indian systems of medicine and homoeopathy. The four research Councils, viz. (i) Central Council for Research in Ayurveda and Siddha (CCRA & S); (ii) Central Council for Research in Unani Medicine (CCRUM); (iii) Central Council for Research in Homeopathy (CCRH); and (iv) Central Council for Research in Yoga & Naturopathy (CCRYN), initiate, aid, guide, develop and co-ordinate scientific research in different aspects-fundamental and applied-of the respective systems. Registered under the Society's Registration Act, 1860, these Central Councils are administered by the respective Governing Bodies, and are the apex bodies for research in the concerned systems of medicine.

MINISTRY OF INDUSTRY

The Ministry of Industry, constituted on 23 August 1976, comprises two Departments, namely Department of Industrial Develoment and Department of Heavy Industry.

The Department of Industrial Development is the primary Government agency for the formulation and implementation of Government's industrial policy, including the promotion of industrialisation of the country in accordance with Government's industrial policy, national priorities, objectives of the Five Year Plans, etc.

There are a number of development and promotion organisations attached to the Department. The important organisations under this category concerning S&T are Directorate General of Technical Development (DGTD), New Delhi, and Patent Office, Calcutta.

The Directorate General of Technical Development (DGTD) is the principal technical advisory organisation in the industrial field to various Ministeries/Departments of the Government. It gives technical advice on matters relating to industrial technology and licensing, foreign collaboration, capital goods requirements, import and export policy, tariff structure and related matters in respect of most of the industries, excepting iron and steel, textiles, jute, sugar and vanaspati. It is also entrusted with the task of making recommendations on the development plans for various industries. Further, it monitors the implementation of various manufacturing schemes and production of industries.

The Patent Office, Calcutta deals with the grants of patents for the new inventions under the Patent Act, 1970 and registration of industrial designs under the Design Act, 1911.

The Office of the Development Commissioner (Small Scale Industries) attached to the Ministry of Industry is the nodal agency for co-ordinating the policies and programmes for the development of small scale industries in the country. There are several allied institutions like Central Institute of Tool Design, Hyderabad, Central Tool Room and Training Centres at Ludhiana and Calcutta, Hand Tool Institute, Jullandar, Institute for Design of Electrical Measuring Instruments (IDEMI), Bombay, and Small Industries Training Institute (SIET), Hyderabad, which provide training and technical services in specialised fields.

The Khadi and Village Industries Commission under the Department plays a pivotal role assigned to it in rural industrialisation. Several multi-industrial zonal training centres have been set up for meeting training needs in this area.

The Department of Industrial Development also provides organised institutional services for the purposes of training, research and design through a series of specialised institutes. The four important institutes in this area are as follows. The National Institute of Design, Ahmedabad, set up in 1961 is an autonomous national institution for education, research service and training in industrial design and visual communication. The Cement Research Institute of India, an autonomous body registered under the Societies Registration Act, 1860, is an R&D institute at the national level and is devoted primarily to intensive and co-ordinated research in the manufacture and utilization of cement. The Cement Pulp and Paper Research Institute is also autonomous body set up with the aim of promoting research and other scientific work connected with pulp and paper industry, and to establish and maintain laboratories pilot plants, workshops and conduct experiments. The Indian Plywood Industries Research Institute, Bangalore, registered under the Societies Registration Act, is engaged in developing new adhesives and in effecting improvements in the known formulations, and in studying the physical amd mechanical properties of wood, plywood and other wood-based panels. The Indian Rubber Manufacturers Association, Thana, is another voluntary organisation which came into existance in 1959 and was shifted to Department control in 1978.

The Appropriate Technology Cell, constituted in the Ministry of Industry on 1 February 1971, has the following objectives : (i) to compile existing information on appropriate technology; (ii) to identify special areas wherein the methodology of appropriate technology would yield greater employment opportunities; (iii) to carry out preliminary cost studies and other economic investigations; (iv) to encourage adoption of appropriate technology

models in selected industries; (v) to coordinate research projects and undertake field testing of prototypes; etc.

MINISTRY OF INFORMATION AND BROADCASTING

The objectives of the Ministry of Information and Broadcasting are to inform, educate as well as entertain with a view to creating awareness among the people about the nation's potentials for development and its problems, widening their horizon, and soliciting their participation in the implementation of policies, plans and programmes of the Government so as to bring about economic development and social change, and achieve national security and promote national integration.

The R&D work of the Ministry is limited to All India Radio. The Office of Research Engineer under All India Radio was set up in 1937 in New Delhi to investigate problems concerning technical operations, maintenance of and improvement to the sound broadcasting services of this national network. It also undertakes design, development and fabrication of broadcasting and electronic equipment in addition to instrumentation before any new service is introduced.

MINISTRY OF IRRIGATION

As an independent Ministry headed by a Cabinet Minister, Ministry of Irrigation came into being on 9 June 1980 with the separation from what was then "Department of Irrigation" from the Ministry of Irrigation and Power. A subsequent development took place in July 1980 when Ground Water Development, Minor Irrigation and Command Water Development Programme were also transferred to the Ministry of Irrigation from the Ministry of Agriculture. The Ministry is responsible at the national level for laying down policies and programmes for development and regulation of the country's water resources-both surface and ground water. It has the role of co-ordination, synthesis and monitoring country-wide irrigation development, including common area development, flood control and drainage.

The Central Water and Power Research Station, established in 1916, has evolved itself into the premier national institution of international status devoted to the development of the country's water and energy resources touching the arteries of the economy at all points. The present applied and fundamental research activities of the station are mainly concentrated around the disciplines of river engineering, reservoir and appurtenant structures, coastal and offshore engineering, ship hydrodynamics, hydraulic machinery, stratified flows, foundations and structures, geotechniques, earthquake engineering, mathematic modelling and

instrumentation. The research station was recognised as the Regional Laboratory of the ESCAP in the area of waterways and water-bone transport.

The Central Soil and Materials Research Station, set up under the Central Water and Power Commission, New Delhi in 1954, conducts basic and applied research in the field of geomechanics and construction materials. The broad functions of the research station are in the four disciplines, namely soil mechanics and foundation engineering, rock mechanics, concrete technology and chemistry & sediments.

MINISTRY OF RAILWAYS

The management of the Indian Railways is controlled and directed by the Railway Board under the overall supervision of the Union Minister for Railways. The Railway Board exercises all the powers of the Central Government in respect of regulation, construction, maintenance and operation of the railways.

The R&D aspects related to railways are looked after by the Research, Design and Standards Organisation (RDSO), which was created in 1957 by merging the Central Standard Office (CSO) and Railway Testing and Research Centre (RTRC). The RDSO has now grown into a fully equipped research organisation of the Indian Railways having experts from all the disciplines of the railway working, such as architecture, coaching stock, civil engineering (permanent way, bridges and tracks), diesel engine development, electrical engineering (locomotive, train lightening and air-conditioning), electrical traction installation, metallurgical and chemical motive power (diesel, steam and cranes), signal and telecommunication, traffic research, and goods stock.

The Director of RDSO holds the status of an advisor and consultant to the Railway Board, the Zonal Railways, production units and other railway users on technical matters.

RDSO is afforded guidance in carrying out research and development activities by the Central Board of Railway Research (CBRR), which consists of eminent scientists, technologists, engineers and senior executives from other research organisations, universities and industries connected with railway technology and equipment. CBRR functions under the chairmanship of the Chairman of Railway Board, and the Director of Research of RDSO functions as member secretary.

MINISTRY OF STEEL & MINES

The Ministry of Steel and Mines has two wings-Department of Steel and Department of Mines.

DEPARTMENT OF STEEL

The Department of Steel has several public sector undertaking in its control. The major public sector undertaking is the Steel Authority of India. It has a major R&D Centre at Ranchi. It has set a modern R&D Laboratory at an estimated cost of about Rs.15 crores and an Information & Documentation Centre. This Centre undertakes the task of technological development through R&D work under the modernisation programme of its steel plants. A number of projects are under way at Bhilai in areas like coke and coal, iron making, steel making, mechanical working, etc.

The Mineral Development Board, which is the centralised agency for ensuring systematic, co-ordinated and integrated development of ferrous and other strategic minerals, also falls under the administrative control of the Department of Steel.

DEPARTMENT OF MINES

The Department of Mines is responsible for the survey and exploration of all minerals, other than natural gas, petroleum and atomic minerals, for mining and metallurgy of non-ferrous metals like aluminium, copper, zinc, lead, etc., and for administration of Mines & Minerals (Regulation and Development) Act, 1957.

The Department of Mines has three subordinate offices, namely Geological Survey of India (GSI), the Indian Bureau of Mines (IBM), and the Controller of Mines Leases (CMIL).

The Geological Survey of India with headquarters in Calcutta is a large multidisciplinary organisation with country-wide coverage and is responsible primarily for geological mining, geophysical surveys, mineral investigation, geotechnical investigation, offshore mineral exploration, and study of marine geology, geothermal investigations, laboratory studies involving petrology, palaentology, geochromology and isotope-geomineral physics, etc.

The Indian Bureau of Mines at Nagpur is also a multi-disciplinary scientific and technical department primarily responsible for the promotion of conservation and scientific developments of mineral resources other than coal, petroleum and natural gas, atomic minerals and minor minerals. It also provides technical consultancy services to mining industry for survey and geological appraisal of mineral resources and the preparation of feasibility reports of mining projects including benefication plants. It also functions as data bank on mines and minerals.

MINISTRY OF COMMUNICATION

The Ministry of Communication consists of two wings: (i) the Ministry (Main) and (ii) the Posts and Telegraphs Department.

The main objectives of the Ministry of Communication (other than the Posts and Telegraph Department) are as follows: (i) operation including planning and development of India's external communications services; (ii) radio frequency management(issue of licences to establish and maintain wireless stations); (iii) co-ordination at the national level in respect of the International Telecomunication Union, Geneva, and Asia-Pacific Telecommunity; and (iv) co-ordination of two public sector undertakings.

There are two public sector undertakings under the administrative control of the Ministry, namely, Indian Telephone Industries Limited, Bangalore and Hindustan Teleprinters Limited, Madras. The Indian Telephone Industries Limited has two R&D Divisions located in Bangalore and Naini.

DEPARTMENT OF POSTS & TELEGRAPHS

The Posts and Telegraphs Department, administered by the Posts and Telegraphs Board, deals with all matters relating to posts and telecommunication in the country.

The Board has under its control the Telecommunication Research Centre, which completed 22 important research projects during 1982-83 and continued to be active in telecommunication research and development and monitoring of the existing systems. Another public sector company under its control is the Telecommunication Consultants Limited. During 1982-83, the company submitted 30 offers in foreign countries and 28 offers in India.

MINISTRY OF PETROLEUM, CHEMICALS AND FERTILIZERS

DEPARTMENT OF CHEMICAL & FERTILIZERS

The work of the Department is divided into three Division - one each dealing with Fertilizers, Chemicals and Drugs. The Department has two attached offices, namely Fertilizer Industry Co-ordination Committee and Office of the Development Commission (Drugs). The Department is responsible for production of fertilizers, drugs and pharmaceuticals, insecticides, molasses, dyestuffs and dyeintermediates, all organic and inorganic chemicals; planning, development and control of, and asistance to, all industries dealt with by the Department; and all attached or subordinate offices and public sector projects concerned with the subjects included under this Department. The Department has 15 companies in the public sector of which nine are in fertilizers, four manufacture drugs and pharmaceuticals, and two produce

chemicals and pesticides. In addition, there is a drugs and pharmaceutical company which is managed by this Department under the Industries (Development and Regulation) Act, 1951. Out of nine companies in the fertilizer field, seven produce fertilizers, one is a fertilizer consultancy company and one is engaged in the mining of fertilizer raw materials - rock phosphate and pyrites.

MINISTRY OF AGRICULTURE

The Ministry of Agriculture consists of two Departments, namely Department of Agricultural Research and Education and Departmnt of Agriculture and Co-operation

DEPARTMENT OF AGRICULTURAL RESEARCH AND EDUCATION

This Department has under its control the Indian Council of Agricultural Research (ICAR), the National Academy of Agricultural Management, and Agricultural Scientists Recruitment Board.

The activities of ICAR have been dealt with under that head. The National Academy of Agricultural Research Management (functioning since 1976) prepares new entrants to the agricultural research services besides giving orientation courses to senior scientists including directors of the institutes. The Agricultural Scientists Recruitment Board (ASRB), set up in December 1973 as an independent recruiting agency of ICAR, is concerned with recruitment of all scientific posts equivalent to class I and above in the field of agriculture, animal husbandry and allied sciences.

DEPARTMENT OF AGRICULTURE AND CO-OPERATION

The Department is entrusted with the task of formulation and implementation of national policies and programmes aimed at achieving rapid agricultural growth by securing optimum utilisation and development of country's land, water, soil, animal husbandry, dairy, forestry and fisheries resources. The Department takes, through all available policy instruments, steps to ensure remunerative return to the farmer for his agricultural produce, and timely and adequate supply of inputs and services. The Department is responsible for participating in the activities of international organisations, and fostering bilateral co-operation in agricultural and allied fields.

The Secretary to the Department of Agriculture and Co-operation is assisted by three additional Secretaries, the Inspector General of Forests, the Agricultural Commissioner, the Chief Agricultural Expert, etc. The Department is organised in 25 functional divisions concerned with the development of different agricultural and allied activities.

SCIENCE POLICY

GOVERNMENT SUPPORT

The importance of science was recognised by the leaders of the country much before India achieved independence. In 1939, the Indian National Congress appointed a National Planning Committee under the chairmanship of Jawaharlal Nehru and invited leading scientists to participate in the formulation of plans of economic development and social betterment. A study group dealt with the problem of general and technical education and scientific research. Besides other recommendations, this group also suggested that the programmes of industrial and educational development should be closely linked with the programmes of scientific research. This line of approach was continued with greater vigour and concretisation in the context of the specific situation. It was clearly stated in the Scientific Policy Resolution of 1958 of the Parliament.

The evolution of science policy in India is interesting from many points. At each stage of development of India, since Independence, specific goals were set. When these were reached, or partially achieved, or when they posed new sets of problem, they were received and a new direction was given. In addition, the economic and political developments also brought to surface a set of needs. The science policy evolved as a result of interaction of the two, i.e. internal development of science and technology, and economic political needs. It must, however, be emphasised that the political leadership played a decisive role in assessing the development of science and technology and in directing it into fruitful channels. The active involvement of political leadership, faith in science and technology and an appreciation of its role in development is a significant factor in the development of science in India. This interaction also brought the political leadership and the scientific leadership of the country together, who came to share common interests, goals and objectives. This interaction also came to play a vital role in evolving government policies, particularly in new and emerging areas of science and technology, which required both a far-sighted and imaginative approach on the one hand and a long-term and heavy investment in research on the

other. It was as a result of this interaction that a major thrust was provided, right at the beginning, to such areas as atomic energy, electronics, space, etc. Lastly, another interesting feature of the policy was the involvement of a large number of scientists and technologists in discussions and debates on science policy and science plans at various forums.

The credit for these developments goes to Nehru, who was one of the few, if not the only one, of the political leaders of the world in his time, who had an abiding faith in science and the role which technology could play in national resurgence. He went so far as to say that the future belongs to those who cultivated science and befriended scientists.

Nehru's strategy for the promotion of science and technology and its role in development could be summarised as follows:

(a) Creating social consciousness amongst scientists,by posing social problems before them and asking them to try to find answers. This he did in various meetings he addressed, particularly at the annual sessions of the Indian Science Congress Association, which he made it a point to attend regularly;

(b) Making administrators conscious of the utility of science, through involving scientists in various committees;

(c) Involving scientists in the decision making process;

(d) Using scientific knowledge in the reforms he proposed to undertake, as for instance, in the use of the metric system and the preparation of an Indian calendar;

(e) Giving support to science and technology. He spent a great deal of time and effort in creating a base for scientific and technical research against the opposition of industrialists, administrators and some of his partymen.

As a result of his efforts, a chain of research laboratories were established under CSIR, a number of agencies like Atomic Energy Agency were established, science & technology departments of the universities were expanded, and institutes of technology were created and adequate resources were provided to meet these requirements. Whenever, under great financial difficulties, research institutions' grants were cut, Nehru went out of the way to restore them. He called the research institutes as temples of learning and wanted them to flourish fully; and

(f) Promoting scientific temper. Nehru knew that science could not flourish merely by creating an infrastructure in a society which was steeped in superstition. He, therefore, made considerable effort himself, and

repeatedly pointed out to the scientists the need for the popularisation of scientific outlook amongst the people. He wanted to make science and technology a part of the Indian culture. He considered this to be a critical factor in the development of science and technology in India.

SOCIAL GOALS OF R&D

It would be worthwhile to briefly describe the phases through which the goals of R&D in the country have evolved. These were:

(a) Creation of infrastructure for research;
(b) Promotion of research aimed at import substitution and export promotion, to solve the economic problems of the country;
(c) Attainment of self-reliance;
(d) Science for the people; and
(e) Promotion of basic research and international impact.

INFRASTRUCTURE

The first phase of the development of science and technology was the establishment of infrastructure for research and development The rapid developments of different branches of science and emergence of new areas like nuclear energy, electronics, space, etc. during the War created the need to develop suitable agencies to develop these branches. Bhabha's letter to Nehru on the need for creating the finest institutions in India comparable to those anywherelse in the world, which led to the establishment of the Tata Institute of Fundamental Research, clearly indicates the goals of this period. Under the same objectives, a chain of institutes of technology on the model of MIT in USA were created.

The three basic assumptions under which these institutions were created were:

(a) The benefits from science and technology are self-evident and, hence, it must be supported;
(b) Once the infrastructure is created, it would produce results for the benefit of society; and
(c) Science being international, the establishment created as a part of the infrastructure should work in areas which are under study in Western Europe and America in order to keep abreast of them and catch up with their development.

As was to be known later, these assumptions were not valid insofar as the results of researches would not be automatically utilised. The problem of development, as was found by experience, was more complex than initially appreciated. Similarly, it was also discovered later that technology and science have deep social roots

and their full integration in society required a major effort to change the outlook of people.

In addition, there were some unexpected developments. For instance, when advanced centres of education were created it was thought that they would provide the much needed highly skilled manpower for better education, research and industry. However, those who came out of the advanced educational institutions migrated to Western Europe and USA to continue their scientific career there. Even those who remained and worked in India, or those who returned after a prolonged stay abroad, engaged themselves only to keep contact with R&D institutions overseas in areas of relevance to the advanced countries. This reduced the impact of technology and diminished the role of indigenous R&D establishments in the generation of technology and its utilisation for the development of the country.

The policy of import substitution and export promotion was adopted during the late fifties and early sixties when India was faced with a severe crisis of foreign exchange. In such a situation, the question of contribution of R&D institutions was raised in the Parliament. The scientific community reacted to this by reorienting their programmes to suit the goals of research so as to meet the needs of economy. As a result of these questions and debates, a major shift in the thinking of the scientists became evident and was reflected in the R&D programmes. More and more scientists started talking and working on research programmes aimed at import substitution or export promotion.

Later, the further development along these lines led to a well defined policy of self-reliance. A clear-cut expression of these requirements and policy was available in "Approach to Science and Technology Plan", a document prepared by the National Committee on Science and Technology as the basis for the preparation of the 5th Five Year Plan.

The period of the Fifth Five Year Plan was also a period of intense political changes in the country. It was marked by the struggle for power between the more conservative and radical wings of the ruling political party. This political struggle had its reflection on the science policy also. The later was reflected in the election manifestoes of different political parties for the 1971 election. As the political events sharpened the question, the role of science came increasingly under discussion and a number of questions were raised:

Science at what cost, for whom and for what purpose?

This led to considerable debate on the nature and character of science and technology. The debate was initiated by a paper on "Alternative Technology" presented to One Asia Assembly. The debate on the document "Approach to Science and Technology Plan" also raised some of these questions in the context of working

out priorities for science and technology. The debate and the ideas generated by it led to a number of new experiments. At the initiative of the Prime Minister, the Indian Science Congress Association devoted its 1976 session at Waltair to the problems of rural technology.

SUPPORT TO BASIC RESEARCH

The experience of using science and technology for rural development and for the uplift of down-trodden brought to surface the fact that problems of the down-trodden and of rural areas cannot be solved through the use of outdated science and technology. These, it was realised, require most sophisticated science and technology. Further, in addition to finding technical solutions, the latter require to be integrated with social conditions and economic constraints, besides a proper delivery system. Consequently, the need for long term and basic research interposing natural and social sciences was felt.

The Sixth Plan for science and technology laid, as a result, a greater emphasis on fundamental and basic research. In addition to giving attention to immediate problems and finding their solutions with available knowledge, considerable effort was proposed to be directed to long-term problems and their solutions, by generating necessary knowledge and technological capabilities.

Further, three new dimensions also came to be incorporated in the science policy as a result of past experience, new needs and new perceptions. These were connected with the problem of safeguarding environment, factors arising out of interaction of science and technology with society, and the development of information system and its use in decision making. As a result of these perceptions, policies were evolved taking these into consideration and major changes were effected in the infrastructure of science and technology. New agencies and departments were created to undertake responsibility and promote research in newer areas of science and technology, and greater resources were provided to back research with time-targeted objectives.

In this context, India's organisation and achievement of space research, mining of the sea-bed nodules and Antarctica expedition deserve special mention. These achievements placed India on the forefront of international science.

The phases of the R&D policy in India clearly reveal two things. Firstly, the goals set for by society conditioned the R&D goals. Secondly, the impetus for changed goals was not only due to the result of internal development of science, but mostly as a result of interaction with society and the political leadership, who took the necessary initiative.

COORDINATION

The implementation of the science policy for national development meant effective utilisation of the existing and available capabilities, beginning with the coordination of research effort over a number of institutions and agencies. The first step in this direction was taken in 1948, with the setting up of an Advisory Committee for Coordinating Scientific Work was set up under the chairmanship of the Prime Minister. In May, 1956 this Committee was replaced by the Scientific Advisory Committee to the Cabinet (SACC). The terms of reference of SACC were modified to include problems of international collaboration and policy formulation besides coordination, avoidance of duplication and provision of the necessary support to research.

In 1968, as a result of a Conference of Scientists and Technologists and its recommendation, SACC was replaced by the Committee on Science and Technology (COST). The Committee was charged with the tasks of policy making, its implementation, coordination, correction of imbalances, fuller utilisation of indigenous research, evaluation and international cooperation.

The COST was supported by a stronger Secretariat than the SACC. The membership of the COST comprised the Cabinet Secretary, heads of various major R&D establishments, Chairman of UGC. A new feature was the membership of an economist, some independent scientists and industrialists.

In November 1971, COST was replaced by the National Committee on Science and Technology. This Committee (NCST) had 15 eminent scientists and technologists. The task before the Committee was to revamp scientific, technological and industrial activities both for civil and defence requirements. The functions of the NCST were to advise and assist the Government in preparing a science plan, correcting imbalances, coordination and international collaboration to achieve self-reliance as a major policy issue and the goal was crystallised during this period.

In 1981 the Government constituted the Cabinet Committee on Science and Technology and the Science Advisory Committee to the Cabinet. The latter has Member of the Planning Commission for Science & Technology as its Chairman.

PLANNING COMMISSION

The role of the Planning Commission in policy making and planning is of considerable significance. During the last three decades, the Commission had evolved an elaborate process for the formulation of plans. The Commission set up various working

groups consisting of experts in different fields to formulate the plan for the relevant sector in collaboration with Central Ministries and State Governments. Likewise in the case of scientific research the Commission set up independent committees, working groups and panels of experts and scientists to suggest plans for various sectors of scientific research.

The Planning Commission takes direct interest in promoting research in specific areas by requesting the establishments to work out specific time-targeted projects, which it funds directly or helps to support them for UNDP-aided prcjects. In addition it selects areas which do not have an institutional base, and helps in bringing scientists together and developing such areas of research. This helps in promoting newer and developing areas of research in the advancing frontiers of science. In this task the Planning Commission is now assisted by the Department of Science & Technology, which takes the initiative. This is perhaps one of the reasons that scientists working in the advanced areas are able to gather support and build up institutions of research and India is not lagging behind other advanced countries in most of the advanced areas of science and technology.

REVIEW OF SCIENCE POLICY

The science policy is reviewed periodically at various levels. At the political level, it is reviewed by various Parliamentary Committees. Overall, the science policy is also reviewed by special conferences, organised by the Government, where eminent scientists, technologists and educationists are invited. Occasionally, special committees are set up to review the progress in specific fields and areas or the functioning of institutions or agencies. These steps are aimed at reviewing the development, to evaluating the status of scientific research to identify the gaps, and to laying down the priorities in the context of ever-changing socio-economic needs. These reviews also enable fixing the norms and guidelines for future scientific programmes.

Parliament

The Parliament acts as a watchdog on matters related to science policy development. It discusses, in general, science policy issues and development of science. The extent of Parliament's interest is manifested in the kind of debates, call attention motions and adjournment motions, etc. concerning scientific departments, their functioning and activities. It also debates the performance of these departments while taking up their demands for grants. Apart from studying other Government Departments, Parliamentary Committees like Public Accounts Committee and the Estimates Committee study the working and financing of the scientific departments and present their reports to the Parliament. Informal

Consultative Committees consisting of Members of Parliament help each Ministry in integrating political and social decisions with the science policy.

The Indian Parliamentary and Scientific Committee consisting of Members of Parliament and scientists keeps the parliamentarians informed about current scientific matters so that they may be able to play their role effectively.

SPECIAL CONFERENCES

For the successful implementation of the Scientific Policy Resolution and to work out a plan for action it was necessary to identify the tasks involved. The Government of India organised the First Conference of Scientists and Educationists under the auspices of Ministry of Scientific Research and Cultural Affairs in 1958 to consider the ways and means to implement the Scientific Policy Resolution. The conclusions arrived at the Conference dealt with better scales of pay and service conditions, search for and promotion of talent, more fellowships for research and resources for equipment, and proper coordination between resources of man and materials. The Conference also recommended greater mobility amongst scientists in various sectors, facilities to be created for manufacture of instruments and collection, storage and dissemination of information and promotion of scientific outlook.

The Second Conference of Scientists and Educationists was organised in 1963 to further review the implementation of the Scientific Policy Resolution. This Conference also recommended better pay scales, better career prospects and recognition of merit and more working facilities.

After reviewing the measures suggested by the First Conferences in conformity with the Scientific Policy Resolution, the Conference recommended greater allocation for research, coordination between scientific and technological agencies, establishment of advanced centres of research in universities, ensuring of mobility of scientists between different sectors of research and incentives to utilise results of research.

A Prime Minister's Round Table Conference on Science and Technology, held in September 1967, made various recommendations dealing with the participation of laboratory scientists in school and college education, greater efforts to be made to popularise science, support to viable groups in universities, greater planning of research in relation to national needs and creation of a National Council for Science and Technology.

The Third Conference of Scientists, Technologists and Educationists was organised under the auspices of the Committee on Science and Technology in 1970. The principal objectives before the conference were to make a comprehensive review of the

progress made in the implementation of Scientific Policy Resolution; to suggest in the light of this review, measures to remedy any lacunae observed in its implementation; to consider the need or otherwise for restatement of Scientific Policy Resolution in order to incorporate policy for technology, and if so, to suggest necessary modification.

The Third Conference made suggestions to obviate bottlenecks in the implementation of various measures arising out of the Scientific Policy Resolution. The important recommendations dealt with the preparation of the S&T plan as part of national plan, evaluation of scientific and technological effort to be made at all levels, integration of various academies to form a national academy, policy of import of technology to be related with indigenous R&D, and proper manpower planning.

TECHNOLOGY POLICY STATEMENT

As a result of three decades of planning, and the Scientific Policy Resolution of 1958, India has a strong agricultural and industrial base and a scientific manpower impressive in quality, numbers and range of skills. Given clear-cut objectives and the necessary support, science has shown its capacity to solve problems.

The Government must clearly define systems for the choice of technology, taking into account economic, social and cultural factors along with technical considerations; indigenous development and support to technology, acquisition of technology through import and its subsequent absorption, adaptation and upgradation; ensuring competitiveness at international levels in all necessary areas; and establishing links between the various elements concerned with generation of technology, its transformation into economically utilizable form, the sector responsible for production (which is the user of such technology), financial institutions concerned with the resources needed for these activities, and the promotional and regulating arms of the Government.

The Technology Policy Statement is in response to the need for guidelines to cover this wide-ranging and complex set of inter-related areas, which was announced by Government of India in January 1983.

The basic objectives of the Technology Policy Statement are the development of indigenous technology and efficient absorption and adaptation of imported technology appropriate to national priorities and resources. Its aims are to:

(a) attain technological competence and self-reliance, to reduce vulnerability, particularly in strategic and critical areas, making the maximum use of indigenous resources;

(b) provide the maximum gainful and satisfying employment to all strata of society, with emphasis on the employment of women and weaker sections of society;

(c) use traditional skills and capabilities, making them commercially competitive;

(d) ensure the correct mix between mass production technologies and production by the masses;

(e) ensure maximum development with minimum capital outlay;

(f) identify obsolescence of technology in use and arrange for modernization of both equipment and technology;

(g) develop technologies which are internationally competitive, particularly those with export potential;

(h) improve production speedily through greater efficiency and fuller utilization of existing capabilities, and enhance the quality and reliability of performance and output;

(i) reduce demands on energy, particularly energy from non-renewable sources;

(j) ensure harmony with the environment, preserve the ecological balance and improve the quality of the habitat; and

(k) recycle waste material and make full utilization of by-products.

PLANNING AND FINANCING OF RESEARCH

Scientific and technological research, if it is to be effective for the promotion of science and technology and utilised for the development of the country, has to be planned. Planning should not be misconceived as an instrument of control but requires to be understood as an instrument of effecting choices and providing a direction. This approach can be seen from the policies evolved, as described earlier, and the thrust provided in different Five Year Plans.

The planning process as adopted in India is a two-way process of giving broad policy guidelines from above and interaction at national, agency and laboratory level with the scientists. Finally, as a result of this interaction when a plan is formulated it is then discussed with scientists at various levels and after their reaction is taken into account, the document is finalised. This is a remarkable process, considering the large number of scientists involved and the size of the country. This democratisation of decision making and involvement of working scientists ensures the latter's effective participation and adds to the vigour of science in the country.

The democratisation of decision-making with regard to the formulation of the national science and technology plan for science and technology was not arrived at in one step. It was part of the evolution of scientific tradition in the country since independence. To begin with, like any other country the formulation of plan was limited to a few top scientists-directors and heads of agencies and officers of the Planning Commission and Ministries. However, as a result of the experience gained and pressures exerted by working scientists, the machinery for the formulation of the R&D plan of research was evolved to its present structure. The formulation of the Fifth Five Year Plan marks a real milestone in the process of democratisation of planning.

The process could be briefly stated as follows:

1. The Government declares its policies, guidelines, and thrusts, which were communicated to research agencies and institutions.
2. The heads of agencies and directors of laboratories are requested to prepare their plans taking the guidelines into consideration.

3. The directors in turn request the working scientists and specialists in different branches of science to prepare the plan of work.
4. The plan of work prepared by different scientists and specialists is coordinated at the laboratory level, and discussed by scientific advisory panels of the respective laboratories comprising scientists and technologists from universities, industries, other research institutions and officers from concerned ministries.
5. The laboratory level plans are coordinated at agency level and are subjected to another series of scruitiny by expert panels.
6. The agency plans are coordinated and scrutinised at the Planning Commission level and finalised and thereafter resources allocated.

SCIENCE IN NATIONAL PLANS

All the national plans have given a significant place to science and technology. The First Five-Year Plan, which started in 1952, gave importance to the establishment of infrastructure. It provided funds for (a) the promotion of scientific and industrial research in the already existing institutions; (b) building of new laboratories; (c) institutiton of necessary equipment to enable the laboratories to function; (d) exploration and survey of resources; (e) utilisation of by-products and local resources; (f) introduction of standardisation; and (g) improvement of techniques in cottage industry.

The most significant aspect during this period was the establishment of a chain of national laboratories and research institutes in essential disciplines, located in different parts of the country.

In addition to objectives initiated in the First Plan, the efforts were directed in Second Plan to strengthen the existing research facilities, coordinate the research programmes among various national agencies; link up the research work at the national level with that at regional and state levels; train and generate scientific manpower in sufficient number and their utilisation; and to provide increasing opportunities to the creative workers.

During the Second Plan period, the Indian Scientific Policy Resolution was announced in 1958. The Resolution clearly indicated the objective to accord a prominent place and priorities for science in the national plans.

The emphasis in the Third Plan was on encouraging basic research in universities and training research personnel and to expand the programme of research fellowships and scholarships; the

development and manufacture of scientific and industrial instruments; and investment in pilot plant trials and full scale field experiments.

During the Third Plan, scientific and technological research started to make perceptible contributions to the development of the country. The growth and development trends were indicative in the method of improved farming; better health and speedier transport facilities; fruitful uses of land and water resources and generation of energy for industrial use.

A large number of management problems had come up during the Third Plan and subsequently most of the problems remained incognizable as the visible return from R&D was not considered a criterion for investment. This attracted considerable public attention. The application and commercial exploitation of a small proportion of the scientific results achieved was seriously looked into, with a view to identifying the causes for the state of affairs. The efforts in the Fourth Plan, were directed to integrate industrial research with programmes of industrial development; achieve greater coordination of inter-laboratory level; and evaluate research programmes periodically at different levels.

In Fifth Plan, a major departure was initiated to formulate science and technology plan. Firstly, a document entitled " Approach to Fifth Five Year Plan" was prepared and widely circulated for comments. Further, a series of meetings were organised to discuss the document in different parts of the country. As a result of comments received and discussions held at the meetings the "Approach" document was finalised and expert panels for different areas of science and technology were formed, who submitted their plans taking the "Approach Document" into account. These plans were then integrated at the level of Planning Commission.

The change of Government in 1977 had considerable consequences on science and technology because of lack of proper appreciation of science and technology by those who came to power. Their impact was felt in terms of policies, organisational changes, provision of resources and general atmosphere, leading to considerable demoralisation of scientists and technologists and even disruption of the institutional structure. The concept of planning though not abandoned was reduced to mere fiscal allocation as an annual plan exercise. However, with the change of Government again in 1980, science and technology and its planning was given a new fillip.

The Sixth Plan followed a different procedure. The Draft Plan was prepared on the basis of the election manifesto of the Congress Party which won the elections and wide ranging discussions with the scientists all over the country. The draft document was circulated widely and discussed in a conference of

300-400 eminent scientists and technologists from different walks of life. The document was finalised by a Panel of Experts formed by the Department of Science and Technology, which was then discussed by the Planning Commission and the modified document included in the Sixth Five Year Plan. The S&T Plan, which is integrated with the national plan, has been formulated with the objective which would subserve those of the national plan during this period.

The main thrust of the Fifth Five Year Plan was removal of poverty and attainment of self-reliance. The main thrust of the Sixth Five Year Plan was growth, modernisation, self-reliance and social justice.

The investment made in different fields of science and technology are indicative of emphasis given to different areas; the relative priorities could be judged in the Tables provided in the end International data are also provided to give a comprehensive picture.

SCIENTIFIC SOCIETIES

The development of science is inextricably linked with the development of institutions in the country. Scientific research organisations, science departments of the universities and scientific societies are of paramount importance in this process. Scientific societies have additionally to contribute to the promotion and development of science. These societies, beside bringing together scientists and technologists to discuss problems and development of knowledge in specific branches of science and technology, also play an important role in organising effective public opinion and support for science.

India has a history of growth of a wide range of scientific societies. They have, in varying degrees of success, over varying intervals of time and in varied ways, carried out active and effective programmes geared to national development.

What follows is a brief account of development of scientific societies in India.

The earliest society to be established in India was the Asiatic Society of Bengal, Calcutta (1784) by Sir William Jones, Supreme Court, who was also its first President. Through the efforts of this society, which incidentally is celebrating this year the bicentuary of its founding, the Indian Musuem was founded in Calcutta in 1866. The Society published in its Transactions papers in physics, chemistry, geology and medical sciences.

Besides the Asiatic Society of Bengal a large number of scientific societies, like the Royal Horticultural Society of India, Calcutta (1860) and the Bombay Natural History Society (1863), were also established. The Indian Association for the Cultivation of Science, founded in 1876 by Dr. Mohandra Lal Sircar, became one of the foremost scientific centres in the country. Mention may also be made of the Ahmedabad Medical Society, which was established in 1902, and of the Calcutta Mathematical Society, which came into existence in 1908.

As a result of the efforts of MacMohan of Lucknow and Simon of Madras, the Indian Science Congress Association was formed in 1914. Later, the Banaras Mathematical Society (1918), the Indian Botanical Society (1920), the Institute of Engineers (1920), the Anthropological Society, Calcutta (1920), the Geological, Mining

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and Metallurgical Society (1924), the Indian Chemical Society (1924), the Sugar Technologists Association of India (1926), the Institution of Chemists (1927), the Indian Medical Association (1928), the Indian Academy of Sciences, Bangalore (1934), the Indian Physical Society, Calcutta (1934), the National Institute of Sciences of India, Delhi (1935) (now the Indian National Science Academy), the Indian Science News Association, Calcutta (1936), the National Academy of Sciences, Allahabad (1936), the Entomological Society of India (1938), the Association of Surgeons of India, Calcutta (1941), and the Association of Scientific Workers of India (1947), were the other important societies established for encouragement and promotion of research in various fields of science and technology.

In the early stages, these societies were only interested in subjects without concern for benefits or applications of research results. In course of time, however, attention was paid to the use of scientific results for societal benefit, and such applications of research were also highlighted. In addition, studies of natural phenomena, exploration of land and sea and the skies, and identification of new species of plants and animals were also part of their interests.

Many societies also used their media, such as publications and lectures as well as exhibitions, as a means of informing the public of the results of their activities. Education of the public, therefore, also became an increasingly important field for societies. As education became more formalised through universities and training institutions, it was but natural that those engaged in teaching and training also became active members of the societies. In general, research and teaching became integrated and the Societies offered a forum for discussion not only of research results, but also of the standards of teaching and of constant updating of teaching material.

These societies also became centres of active cooperation among scientists, especially among those who were considered leaders in their profession. Through a system of identification of excellence and of encouragement, the societies also came to be regarded as centres of authoritative knowledge in particular fields in science. Various public organisations engaged in education or training as well as government organisations involved in exploration, identification of new areas for science for support or for investments in the use of science and technology for economic and social benefit, tended to seek advice either formally or informally from these societies. Individual scientists working in government and educational agencies through the medium of such societies had opportunities to obtain authentic information from colleagues and very often valuable information from international sources through connections established by various members of such societies.

Four types of scientific societies have come into being: Firstly, those which are honorific, whose members are elected for their distinctive contribution to science, like the Indian National Science Academy; secondly, those societies which represent a branch of science where any one belonging to this discipline could become a member; thirdly, professional bodies, like the Institution of Engineers and Medical Council of India, which ensure professional standards, their promotion and development; and finally, associations and societies, in large numbers, which propagate, and promote science and its interaction with society. The last category includes: Forum of Science Technology and Society, New Delhi; Science Circle, Bangalore; Association of Scientific Workers of India; etc. These societies could act as highly knowledgeable institutions and influence, both formally and informally, the policy-making systems on aspects pertaining to the areas of research, choice of technology, and organisation of research and development. Although these societies are primarily concerned with the professional development of their members, they also act as effective instruments for creating a social climate for science.

SCIENTIFIC LITERATURE AND INFORMATION SYSTEM

The efficacy of the scientific community and the level of its interaction with the decision-making system as envisaged by the Scientific Policy Resolution depend upon the S&T information level. The first conference organised to review Scientific Policy Resolution recommended the creation of a National Institute for S&T Information. This still remains to be implemented. The information level of a society depends on the availability of literature, produced by other countries as well as the concerned country. India has been able to maintain good libraries, where most of the important scientific and technical literature is readily available. Further, it has now been able to organise the publication of scientific and technical information generated in the country.

The organisation of documentation and dissemination services, which determine the degree of utilisation of literature, leaves much to be desired. One major limitation of Indian scientists is their over-dependence on English literature. Literature in other important languages, such as Russian, French, German, Japanese, Chinese, Spanish, Arabic and other languages, is either not available or when available, it is not widely utilised for lack of translation facilities or because of the scientist's not knowing any language other than English.

The utilisation of literature is also limited owing to antiquated methods being followed in storage, retrieval and analysis of available information. Much progress is required in the organisation of facilities for such services to make effective use of available information and the resources spent on procurement of material.

The Scientific Policy Resolution, when it mentioned the use of science and technology to bring about a major change, implied the use of information and knowledge in decision making. In other words, it implied the development of an information culture as a basic element of scientific ethos. Progress in this direction has been halting and limited. This, both in terms of organisation of an information system and in the use of available information.

PRODUCTION OF SCIENTIFIC LITERATURE

A number of published books continues to be on fiction, travelogues, anthologies and religious books. Books on science and engineering subjects, though less in number as compared to other fields, are being published in increasing number. However, a large proportion of science and engineering books are school and college level textbooks, written both in English and in the Indian languages. There are also translations and reprints of foreign textbooks. A good number of science books are manuals and handbooks, mostly for use by machine operators. This is a healthy sign and is directly linked with the spread of literacy and professional education. A number of State Governments publish school textbooks.

Government publications, both Centre and States, form a sizeable proportion of the total science and technology literature. These are generally annual reports of various departments and agnecies of the Govenment, survey and study reports, reports of committees and commissions, and publications of statistical nature and of standards. However, they do serve as a unique and most authentic source of scientific and technical information.

A larger proportion of scientific publications are in the applied sciences such as medicine, engineering and agriculture. These three fields together account for about 50% of all scientific books published. In the fields of medicine and agriculture, the proportion of books in the Indian languages is quite high. However, most of the Government publications continue to be published in English.

CSIR, amongst the scientific agencies, has a major programme of publication. Besides the Wealth of India, an encyclopaedia of raw materials and industrial products, CSIR publishes a large number of specialised monographs of reference value to teachers and research workers alike.

The production of Indian scientific book fails to show any clear-cut trend of increase in volume. The book trade has been complaining of limited market, except of textbooks, within the country. Because of the step rise in prices, only the libraries are the main buyers.

So far as users of scientific literature within the country are concerned, it has to be admitted that they still have to depend on foreign literature to a large extent. Indian publications form a small proportion of the collection in most cases. This is also reflected in the citations of the Indian authors.

In the above estimates, patents literature has not been taken into consideration, which has been increasing in recent years. According to WIPO estimates, India had produced 3000 patents up to 1980. The topmost contributor, Japan, produced 30,000 patents up to the same year.

TABLE 1

Growth of Scientific Journals, 1959 to 1976

Subjects	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	Total
5/6 Science & Technology (General)	1	2	3	2	3	7	6	4	3	3	4	1	8	8	1	1	3	-	60
51 Mathematics, Astronomy	1	-	-	2	4	1	-	2	3	1	1	1	-	1	1	-	-	-	18
53 Physics	1	-	-	-	1	-	-	1	-	-	-	1	-	-	4	-	-	-	8
54 Chemistry	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
55/56 Geology, Meteorology, Palaentology	2	1	-	-	2	3	6	2	-	4	2	1	3	2	1	2	-	-	31
57 Biological Sciences	1	-	1	-	3	1	-	-	-	-	2	1	-	-	-	3	2	-	14
58 Botany	1	-	-	2	-	-	-	1	-	-	-	2	2	1	2	4	-	-	16
59 Zoology	1	2	-	-	-	-	1	1	1	-	-	-	2	-	1	-	-	-	9
61 Medicine	13	9	12	5	6	16	13	5	8	8	14	7	6	7	-	4	3	-	136
62 Engineering	8	8	14	10	8	11	9	9	6	13	9	9	11	7	8	4	2	2	148
63 Agriculture, Animal Husbandry	4	-	9	14	10	9	5	8	9	8	14	13	15	8	10	4	5	2	147
658 6/8 Industry & Trade	2	1	2	4	8	7	3	5	5	-	2	1	6	2	1	-	-	-	49
669 Metallurgy	1	1	1	-	1	-	1	1	2	2	-	1	-	-	-	3	-	-	14
67/68 Manufactures	2	2	4	4	3	4	3	5	10	-	4	6	2	4	-	2	3	1	59
69 Building	-	-	-	-	1	1	-	-	-	-	-	1	-	-	-	-	-	-	3
Total	38	26	46	42	53	60	47	44	47	39	52	45	55	40	29	27	18	5	713

It should also be mentioned that with the increase in the number of research institutions, there has been a growth in the volume of technical report literature and also conference papers, a large part of which does not get into the regular publishing channel and hence is not fully recorded.

Table 1 shows the growth of journals in different subject fields. In almost all the subjects, new journals have been added. However, there has been a greater addition in the area of general science and technology and in the applied fields of medicine, engineering, agriculture and technologies and industries. In fact; about 59% of the Indian journals are devoted to the three subjects of medicine, engineering and agriculture. If we add the journals in general science and technology, then 70% of the Indian journals are concentrated in these four subjects.

Another characteristic of journal publication is that since 1959, 67 new titles in the Indian languages have been added in a total of 713. So far as sponsorship is concerned, only 155 titles, out of 713, are being published by private publishers. The remaining titles are being published by societies, institutions (both public and private), government departments and agencies, universities and colleges and so on. However, publishing of scientific journals is yet to become a commercially viable activity. In this context, the role of Publications & Information Directorate (PID) of CSIR in promoting a number of highly successful Indian scientific journals may be specially mentioned.

Since 1959, a number of abstracting and indexing journals have been added, including the Indian Science Abstracts (1965). Most of them are being published by libraries and information centres attached to various scientific institutions. Private publishers are yet to make a mark in this important area of publishing.

An estimate of the enormous dependence of Indian scientists on foreign journals is available from a very recent compilation of INSDOC, viz. the Union List of Current Scientific Serials in India, December 1981. This list records the intake of journals in 785 institutions in the country. The libraries of these institutions are getting 11,511 foreign journals and 1,892 Indian journals. Out of the foreign journals, 3,186 titles (28.47%) are from USA and 2,071 titles (15.45%) are from UK.

A look into the contents pages of a number of foreign periodicals, which are very widely used in India, shows that a large number of contributions by Indian authors are published in them. The argument usually advanced by such authors is that they get better recognition and response when they publish outside, since these journals have larger circulation. This argument is also substantiated through a number of citation studies. It has often been seen that an Indian author has a greater chance of being cited when he or she publishes his or her article in a foreign journal.

Another indicator of the volume of journal literature is available from the Indian Science Abstracts. For the last several years, this publication has been listing about 1200 entries per month. Most of the entries are journal articles from Indian scientific periodicals, with some being theses, standards and patents.

GROWTH OF DOCUMENTATION ACTIVITIES

To sustain effectively the increased R&D activities and to build up the necesary infrastructure facilities, the need to strengthen documentation and information services is increasingly being felt. It is true that along with every new research organisation, some kind of documentation and information facilities have also been created. Some of them have built up very good collections, and provide services beyond the immediate range of their respective organisation. Mention may be made of the library and information facilities of CSIR laboratories, in particular INSDOC, Bhabha Atomic Research Centre, Defence Research & Development Organisation (DESIDOC), Indian Space Research Organisation, Indian Agricultural Research Institute, Directorate General of Health Services (National Medical Library), National Institute of Health and Family Welfare, Small Industries Extension Training Institute (SENDOC), and Indian Standards Institution. Some of the facilities in the CSIR laboratories serve as national information centres in the areas of their specialisation.

TOWARDS A NATIONAL INFORMATION SYSTEM

The developments in science and technology and related developments, recounted earlier, have considerably changed the documentation scene. This, in turn, made planners for documentation facilities realise that the time was ripe to think along the lines of integrating the different agencies and facilities, which developed in response to the information requirements of certain major sectors of activity, and bring about a well-knit national information system. Developments in the international field also suggest a similar course of action. Even in advanced countries like the USA and Britain, where documentation facilities were well developed, efforts to integrate the different facilities into a national system have been initiated.

The launching of the NISSAT plan was considered by a number of committees set up by the Government of India and the CSIR. Finally, the National Committee on Science & Technology (NCST) recommended, in 1973, a plan for a National Information System in Science and Technology (NISSAT). This plan formed a part of the

Science and Technology Plan. The implementation of the NISSAT Plan has been entrusted to the Department of Science and Technology. The component of NISSAT have been envisaged to be in several tiers or levels. A number of National Information Centres (NCs), such as INSDOC, National Medical Library, the proposed National Agricultural Documentation Centre, etc. were envisaged. At the second level, a number of Sectoral Information Centres (SCs) in such fields as leather, aeronautics, food, drugs, metallurgy, etc. were proposed. At the third level, the Local Information Units (LIUS) attached to the various scientific institutions were envisaged. The NCs may establish a number of Regional Information Centres (RCs). The System has also been envisaged to be a federation of a number of diverse components operating under a variety of ownership and jurisdiction. They are expected to collaborate under the guidance of a coordinating agency. Where necessary, the existing centres would be upgraded and the facilities augmented to help attain the stated objectives.

While the NISSAT Plan has been accepted in all quarters, efforts have to be made for speedier implementation of the Plan in order to realise the benefits. In addition to NISSAT, the Department of Electronics has organised a National Informatics Centre. The problems of overlap and coordination between the two systems are, however, to be resolved.

PARTICIPATION IN INTERNATIONAL SYSTEMS

Integration of the documentation and information facilities into a national system, it may be emphasized, is not only for the effective channellising of relevant information to different points and recipients within the country, but is also aimed to bring benefits from other national and international information systems, namely INIS and AGRIS, and is prepared to participate in the SPINES system. The full benefits of such participation will be available to a large number of people when a well-knit national system is organised. Input to the systems will also improve.

Towards Computerised Services

India is now entering into the new era of computerised documentation services. In a number of scientific libraries and information centres, efforts are under way to use the available computer facilities for documentation activities. Mention may be made of INSDOC, BARC, BHEL, Physical Research Laboratory (Ahmedabad), DESIDOC, National Informatics Centre and ISRO. INSDOC has started an SDI (Selective Dissemination of Information) service based on three important commercially available data bases. Expertise for preparation of computerised indices, directories, etc. has also been created at INSDOC and several other places.

NATIONAL SCIENCE LIBRARY

Another important recent development is the National Science Library (NSL). INSDOC has been slowly building up the basic collection of this projected library for the past several years. When the NSL is fully operational, it is expected to augment the services and influence the functioning of a large number of scientific libraries in the country. It would also be possible to provide a speedy document copying service from NSL to the entire scientific community. In addition, it would build up national collections of several categories of specialised documents which individual libraries cannot hope to procure.

EMPHASIS OF INFORMATION PROCESSING

It is generally believed that the activities mentioned above and similar activties benefit all those who are interested in R&D information. Science planners and decision makers on the one hand, and farmers, artisans and similar categories of poeple on the other hand can hardly benefit from the presently available information services. To be able to serve these categories of information users, more emphasis on information processing has to be given. To satisfy the first category of people, available information has to be processed to generate useful reviews, trend reports, forecasts, etc.; whereas for meeting the needs of the second category of people, information requires to be processed differently, and perhaps presented through simple audio-visual media.

TRAINING OF INFORMATION WORKERS

This raises the question of properly equipping the documentation and information personnel for carrying out jobs mentioned earlier. The information personnel require an adequate mix of a number of skills and expertise. Facilities and methods of training and education of library and documentation workers need to be given a serious thought.

NEED FOR A NATIONAL INFORMATION POLICY

If information is to serve as a national resource for the benefit of the whole country, then there is an urgent need to formulate a national information policy. Like the Industrial Policy Resolution, Scientific Policy Resolution and Technology Policy Statement, there is a need, to have a National Information Policy Statement, inclusive of the machinery for its collection, storage, retrieval and analysis as well as its utilisation for decision making at various levels.

CONTRIBUTION OF INDIGENOUS R&D TO INDIA'S DEVELOPMENT

When India became free, it hardly had any industry and whatever existed was run and controlled by non-Indians. Today India is considered as the 10th largest industrial country in the world and all the industries are manned by the Indians. To start with, India's industrial development began with import of technology, but gradually imported parts are being replaced by indigenous components.

A question has often been asked as to why India should invest in research and development. It is argued that the available technical know-how should be purchased to gain time and further development. The experience over the last three decades, however,has increasingly shown that even for making a correct choice in import of technology, highly professional and technically competent research & development groups are necessary. In the absence of such a body unsuitable,outdated, overpriced technology were purchased. In many cases, an industry which was being scrapped due to obsolete technology and uneconomic production was sold, causing considerable problems.

Secondly, the terms and conditions of the sale of technology are often so restrictive that its further development, and transfer within the country, and sale of products to other countries is not permitted. These restrictions came effectively in the way of industrial development, as has been shown by experience over the last three decades.

Thirdly, many of the machines imported are found to be less useful under the climatic conditions, level of development of the country, social conditions, raw materials available, or nature of materials for which the machines are to be used. The restrictive conditions have come effectively in the way of their development to make them suitable for conditions under which they are to operate and thus make them more efficient.

Lastly, the needs of people, cultural factors, traditions and other features make the technology imported from Europe and America unsuitable to meet the requirements of the people. The imported technology in consumer area can and in fact meets only the requirement of a few affluent groups, leaving the masses and their needs unmet.

The developments since independence have been not only many but vary in nature. These aimed at or met the requirement of developing indigenous capabilities, providing opportunities to people to realise their creativity, meeting the demands of industry, or needs of people, and generally, developing a better India.

How has the investment in science and technology repaid? How much and in what areas it has contributed to national development? It is difficult to fully assess the contributions, particularly in view of the fact that since these cover wide-ranging areas, such as giving expert advice, providing consultancy and turn-key jobs for the industry. The industry ranges from cottage scale to small-scale and to well-organised industry. The R&D institutions, besides building up capabilities of most sophisticated testing, such as those in the area of aeronautics and beneficiation of ores and other materials, have also undertaken turn-key jobs and provided the know-how, design and even fabrication of large scale industrial plants. Some idea of the scale of activity and contributions can be had from the data on patents, processes and innovations, consultancy services and publications.

It is not be possible to list all the achievements of the Indian scientific and industrial developments, but the examples given from a few selected areas should suffice to provide an idea of the capabilities developed and significant achievements.

AGRICULTURE, ANIMAL HUSBANDRY FISHERIES AND FOOD

The main objective in the field of agriculture was to achieve self-sufficiency in foodgrains. The production of foodgrains as a whole has increased from nearly 55 million tonnes in 1950-51 to more than 130 million tonnes in 1980-81. This improvement in foodgrains production has been made possible by the development of high-yielding crop varieties and improved production technology through sustained research effort. As a result of these developments, India has achieved self-sufficiency in food.

India is one of the major centres of the origin of several important crop and animal species, thus making it a large natural germplasm bank. The diversity in plant and animal kingdom is further accentuated by varied soil and agro-climatic conditions in the country. Gene sanctuaries are being established to preserve the rare species in the natural habitat for use in the crop improvement programmes. A Bureau of Plant Genetic Resources , set up in 1976, organises exploration and collection of germplasm, documentation, and quarantine etc., in collaboration with International Plant Genetic Resources Institute. Similar bureaus of fish and animal genetic resources are being set up to preserve the indigenous breeds/strains of a large variety of animal species.

Research in the field of soil productivity has been directed towards survey and mapping of soils, survey of micro-nutrients of soils, correlation of soil tests with crop response, and improvement

of soil structure in problematic areas, etc. The vast soil resources of the country have been systematically surveyed for preparing an inventory of soils of various regions, identifying their production potential and planning for scientific land-use and conservation. The country has been divided into 186 land resource areas, and the soil map for the entire country is expected to be ready in the near future. Notable success has been achieved in reclamation of saline/alkaline soils and use of saline/sodic waters.

The repatterning of the genetic architecture has been an important factor in increasing productivity of crops during this century. Hybrid maize, dwarf rice, hybrid sorghum, hybrid pearl millet, dwarf wheat, hybrid cotton etc., are some of the important development milestones. Research efforts are concentrated on developing plant types to suit various agro-ecological and management conditions prevailing in the country. The development of triple-gene dwarfs in wheat, composite varieties of maize, varieties containing high lysine content, the long-staple cotton varieties, and development of hybrid cotton have further added to the total productivity of the crops in the country. Breakthrough in crop production was also possible owing to systematic efforts on plant protection research through multiple programmes, such as breeding resistant varieties, chemical control methods and cultural methods. Significant success has been achieved in combating the menace of diseases and pests through the development of resistant varieties in rice, wheat, gram, potato, okra, arhar, etc. Some of the pests like Pyrilla pest of sugarcane, pink bollworm of cotton, castor-semi-looper etc., have also been successfully controlled through biological control methods.

Research in animal husbandry has been stressed in the current plan mainly on achieving higher productivity through genetic improvement, improvement of animal health and better mutation and dairy technology. As a result, emphasis is placed on selective breeding in some tracts of indigenous breeds and cross-breeding of non-descript cattle on an extensive scale. The cross-breeding of indigenous cattle with exotic breeds and similar methods made in other anial species has resulted in improved strains like Karan Swiss and Karan Fries in cattle, Avikalin and Avivastra carpet wool strain of sheep, ILI-18 and IBL-18 strains for broiler and layers in poultry. Improvement in buffalo is likely to make greater strides through a recent perfecting of the semen preservation technique. Animal health has received greater attention since a variety of disease pests and diseases affect the livestock. Tissue culture vaccine against foot and mouth disease of cattle, goat disease vaccine for rinderpest, and oil-adjuvant vaccine for haemorrhagic septicaemia of cattle and buffalo are some of major advances in Indian research. Vaccines have also been evolved for lung worm diseases in sheep, swine fever in pig, and Ranikhet and Marek's

diseases in poultry. In the dairy technology, new processes have been developed for production of different milk products, detection of adulteration, extraction and purification of rennet used for production of cheese, and prevention of oxidation of milk and milk products.

Work in fisheries is focussed mainly on marine and inland fisheries and fisheries technology. The major achievements in this area include introduction of induced fish breeding technique using the pituitary gland injection for producting fish seed, establishment of a miniature "Pituitary Bank", development of advanced technology for culturing prawns, mussels, eels and natural pearls. New designs of fishing gear have also been introduced.

In the area of farm machinery and implements, several useful machines and implements have been produced. Some of the notable achievments in this area are: bullock-drawn sweeps; chisel-plough, puddler, manual and animal drawn seed-cum-fertilizer drill, power tiller operated paddy harvester, tractor oriented reaper-binder, multi-crop thresher, etc. Besides, several tools have further improved namely hand hoes, ploughs, harrows, cultivators, etc. In the case of processing equipment, several innovations have taken place. Mention can be made of equipments like grain dryers for cereal crops, groundnut decorticator, sun-flower and groundnut cracker, etc. Several designs of cowdung and biogas plants have been developed and simple technologies have been worked out to recycle agricultural wastes.

Major new thrusts have been given to agricultural research in the country which includes areas such as conservation and strengthening of ecological infrastructure, raising the yield potential of crops, enhancing stability of production, improving post-harvest technology, energy management in agriculture, and strengthening of transfer of technology. A major programme is being launched in the field of biotechnology as applied to agriculture to undertake basic work in areas of molecular biology, genetic engineering, biological nitrogen fixation, photosynthesis, and protoplastics, etc.

RURAL DEVELOPMENT

As a large part of the India consists of its rural hinterland - nearly 80% of the population live in rural areas - rural upliftment is a priority sector for national development. A large number of S&T programmes for rural development have been sponsored under the auspices of CSIR, ICAR, ICMR, DST, KVIC and the Department of Rural Reconstruction. The basic objectives of these programmes are: to generate rural technology to meet local needs, based primarily on utilization of local raw mateials and energy sources as well as on existing and upgraded local skills; and to

promote cooperation between S&T field agencies and generators of indigenous technology in laboratories, educational institutions,etc. A number of schemes relate to the development of relevant technologies for landless labourers, artisans, small and marginal cultivators and tribal communities; the setting up of Krishi Vigyan Kendras, the Lab to Land agriculture programmes of the ICAR, Polytechnology Transfer Centres of the CSIR; Training of Rural Youth for Self Employment (TRYSEM). of the Department of Rural Reconstruction, Health for All programmes of the ICMR, etc.; Integrated Rural Development Programmes, etc. The areas in which a number of appropriate technologies have been developed are: leather industry, for which curing, preservation, tanning techniques have been developed; pottery making; processing of cereals and pulses; production of matches as a cotage industry; fire works; soap making with non-edible oils; hand-made paper, bee keeping, coir and other fibre making industries, biogas, lime manufacture, blacksmithy, carpentry, etc. The KVIC has been able to take the relevant technologies to rural areas with the help of its regional offices located all over the country.

These examples are illustrative of some of the programmes taken up by governmental, non-governmental and voluntary agencies on the application of S&T for rural development. There is, however, more to be done to make innovations and inventions where the scientific method can be applied to produce improvements in the way of life in rural areas.

MEDICAL AND HEALTH SCIENCES

In the medical field, major research efforts have been promoted through Indian Council of Medical Research. The research priorities of the ICMR coincide with the national health priorities and cover the control of communicable diseases, fertility control, promotion of maternal and child health, control and prevention of nutritional and major metabolic disorders and non-communicable diseases such as cancer, cardiovascular diseases, blindnes, diabetes, drug research (including the traditional system of medicine), and developing alternative strategies for health care delivery systems through the primary health care approach.

In the area of communicable diseases, the research efforts have been intensified on major communicable diseases like tuberculosis, leprosy, cholera and diarrhoeal diseases, viral diseases,malaria, filariasis and other parasitic diseases. Some achievments have been made in the control of these diseases. A new sense of hope has been generated for the control of leprosy through work in the field of anti-leprosy vaccines. Combination drug therapy with rifampicin, clofazimine, diprone and other

chemotherapeutic agents in suitable combinations is being employed to bring down the infection load in the community. Similarly in the case of tuberculosis, one of the research centres has discovered that ambulatory, domicialiary treatment of tuberculosis is highly effective without the risk of infection for family contacts. These findings constituted a major departure from the traditional sanatorium treatment and offered new avenues for nationwide programmes for the control of tuberculosis in developing countries. Equally spectacular results were obtained in the initial stages in the control of kala-azar as a fallout of the malarial control programme.

The regulation of human fertility in the interest of the society and indeed of the future of man is the most crucial issue of our time. Indian scientists are working on the broadening the range of methods of contraception. A simple reliable and inexpensive diagnostic kit has been developed by Indian scientists, which should facilitate the medical termination of pregnancy at an early stage when the safe vacuum suction method can be applied.

Malnutrition continues to be an important contributory factor to much of the mortality and morbidity, especially in mothers, infants and young children. Researches carried out by Indian scientists have proved that nutrition needs of infants can be met effectively from locally available and culturally acceptable low-cost foods. Effective methods have also been developed in the country by which blindness can be prevented at the community levels.

In the area of Indian system of medicine, the various schemes included in the Sixth Plan, mainly aim at promotion of research programmes based primarily on respective philosophies, planned production of herbal and other medicines on large scale, and their standarisation. Primarily rural-based research programmes, these systems of medicine are helping to narrow the gap existing in medical care between urban and rural areas.

The government has also recently evolved a National Health Policy which lays stress on preventive, promotive, public health and rehabilitative aspects of health care.

DEFENCE R & D

The visible part of any warfare is the use of arnaments and explosives but behind this activity lies a whole field of research in small arms, guns, ammunition, instruments, ballistics, etc. Some modern explosives have to be delivered by rockets and missiles. A good deal of research is necesary for the manufacture of these missiles and their propellants. One of the prestigious projects on defence R&D relates to the design and development of the main

battle tank, the prototype of which is already ready. Owing to the considerable efforts of DRDO, a sizeable measure of self-sufficiency has been achieved in the areas of small arms and ammunition. The Ishapore rifle, the mountain gun and the Indian field gun mark to which DRDO made significant contributions, are now in use. A self-propelled artillary gun has also gone into production. Various types of proximity fuses have also been developed.

The field of rockets and missiles is a high technology area where a considerable infrastructure has been established and competence built up. Projects under way relate to: competence-building in development of inertial navigation systems, solid and liquid propulsion system, short range rockets and missiles, augmentation of range test facilities, general build-up for development of rockets and missile technology and specific hardware .

Not only radars but even the simple communication systems in use by the Defence Services have to depend upon research in electronics. Some of the important electronic equipment developed in the country are: radars and sound ranging equipment, and communication systems. Work is in progress on some advanced radars and other sophisticated equipment. A secondary surveillance radar has also gone into production in the country.

Research in various aspects of gas turbine engines, its variants and avionics system is crucial for progress in aeronautics. Work has been taken up to a very advanced stage for developing gas turbine engine technology. Flight simulation facilities are being set up and projects for the development of training simulators for two service aircrafts are being pursued. Sophisticated flight simulation facilities for evaluation, design and development of aircraft and systems have been set up. An important project recently taken by DRDO relates to the development of pilotless target aircraft.

The Navy depends upon its effectiveness on technology concerned with physical, chemical and metallurgical aspects and underwater weapons. Various projects to attain self-sufficiency in the field of sonars, torpedoes and other seaborne equipment have been undertaken with considerable success.

ELECTRONICS

India today produces a vide variety of electronics goods and equipments such as radars, television sets, broadcasting equipment, telecommunication, switching and transmission equipment, earth stations, nuclear reactor control power electronics, under-water systems, and so on. A very large part of materials and components required for all these, except for certain specialised items, is produced within the country.

In the component sector, a number of electronics units are introducing new products. Many of these firms have implemented projects in areas like B/W picture tubes, semiconductor devices, carbon film resistors, magnetic tapes, ferrites electrolytic capacitors, PCBs, connectors etc., which are required as a part of the modernisation of the components industry. Efforts have also made towards producing items like professional-grade precision metal film resistors, and plastic film capacitors suitable for communication industry. The major achievment towards production of electronics materials has been the setting up of a copper-beryllium alloy ingot plant. Considerable progress has been made on configuring the National Silicon Facility (NSF), which will undertake stockpiling, production, characterisation and R & D of ultrapure polysilicon, single crystal silicon, silicon wafers, ribbons, etc. as also amorphous silicon. Production of special components/parts of electronic grade alumina, and liquid crystal materials has also been initiated.

The Government has taken steps to modernise the telecommunication industry. Schemes are already under way for setting up manufacture of digital electronic switching systems with foreign collaboration. Many firms have initiated efforts for manufacturing electronic rural automatic exchanges (RAX). In the field of data communications, indigenous capability has been strengthened with the development and systems engineering of message switching systems tailored to the special requirements of the users in the country. Many organisations like Defence, P&T and PTI have already introduced such indigenously designed systems in their network.

The indigenous computer industry has been showing considerable growth both in the area of mini computer/ microprocessor based systems as well as in the mini and midicomputers. Midicomputers are presently being manufactured by ECIL (TDC-332) and ICIM (ICL-2904). The lower and minicomputers are available from indigenous sources to cater to diverse applications like accounting/invoicing machines, word/text processing, programmable logic controller, teaching aids, etc. Some varieties of peripherals like CRT terminals, floppy disc devices, and dot matrix printer are also being manufactured presently. The Department of Electronics has successfully promoted computerisation through a number of its regional centres. Presently, computers are utilised in the country for applications such as image processing, medical diagnostics, training simulators, photocomposition, numerically controlled machines, intelligent testing and measuring equipment, etc. Control and instrument packages are now available in the country to cater to the needs of the modern instrument systems in all the sectors of the industry, and keeping with the trends in technology for

improved systems, upgradation of the existing manufacturing base is under way. The control and instruments systems for off-shore oil platforms and computer based telesupervisory system for cement are some of the new areas of activities intoduced in the country recently.

ENERGY

The thrust of the research efforts in the country in the energy sector has been on improving the efficiency of production, distribution and utilisation of all forms of energy, improvement of energy efficiency in process and equipment, recycling of waste for augmenting energy supply and development of new and renewable energy technologies. S&T efforts in the energy sector have been intensified over the entire range from atomic energy at one end to animal energy at the other. Significant progress has been made in the field of energy production since Independence. This has been largely brought out through considerable efforts on the engineering side relating to construction and commissioning of power stations and transmission networks, etc. R&D efforts other than in the nuclear power sector are comparatively recent. However, over the past decade, major programmes have been initiated in the area of coal mining.

Major efforts have been made to explore high-priority indigenous sources of oil, and significant success has been acheived in off-shore oil exploration and exploitation. This has been accomplished with an increasing degree of self-reliance and self-confidence. The country has developed capabilities for seismic surveying, reservoir engineering, design and fabrication of off-shore platforms and communications systems, ocean engineering for piping oil, and natural gas from off-shore wells etc.

In the Sixth Plan, a significant increase in the allocation and activities has been noticed in the areas of new and renewable sources of energy. A large number of applications have been found useful in the area of solar thermal conversion both for urban and rural areas. A number of large projects have been sponsored by CASE in this area. Two types of solar collectors have been developed and know-how has been passed on to industry. Based on this know-how several demonstration water heating systems have been installed. A solar energy boosted heat pump suitable for generating refrigeration effect has been developed. Under the demonstration and field trial programme in this area, systems like water heaters and dryers, wood seasoning systems, desalination systems, cold storages, power generating systems, pumps etc. are being installed. Several models of solar cookers have been developed in the country. These include simple hot box type solar cookers with one reflector, solar ovens with multiple reflectors,

and solar concentrators. A five-year programme involving the establishment of pilot production facilities and the development and demonstration of solar photovoltaic systems for various applications is being implemented at Central Electronics Ltd.,Ghaziabad since October 1980. A large number of photovoltaic pumps have been made under this programme. Photovoltaic power systems have been delivered for installations on three off-shore platforms of ONGC. Under the field trial and demonstration programmes, photovoltaic water pumps, power systems for lightening, TV and radio units have been installed at different parts of the country. Solar cells presently made in the country are made from single crystal silicon in the form of wafers. An intensive programme of R&D is being carried out with a view to reducing the costs through improved process technologies, improvement in the efficiencies and use of alternative materials. In the materials area, several techniques for the production of high purity silicon for use in photovoltaic devices are being explored.

A major demonstration programme for water pumping windmills is being implemented. Several firms have started development or fabrication of water pumping windmills. Several more prototypes are under fabrication. Integrated energy projects based on renewable energies are being implemented at selected locations with a view to meeting a substantial portion of the total energy requirements of a village. Emphasis has also been given to production and utilisation of bio-energy. R&D on biomass production and conversion including conversion of wood and agricultural wastes, has been intensified and pilot projects initiated. Two new biomass research centres and one wind research centre have been established to undertake mission oriented research, development, and prototype system development activities, leading to commercial production.

ATOMIC ENERGY (R&D)

Indian scientists realised immediately after World War II the role of atomic energy in meeting the energy requirements of the country and set themselves to developing the necessary capability. There was considerable difficulty in getting the necessary know-how owing to secrecy imposed for military reasons and the high level of sophistication of technology. India was able to develop her own capabilities in a short time, with the help of friendly countries for the peaceful utilisation of atomic energy.

Through vigorous R&D efforts over the last 25 years, capabilities have been created right from exploration and mining for atomic minerals, preparation of high purity nuclear materials such as uranium, thorium, plutonium, zirconium etc., production of

fuel elements for reactors, design and construction of power reactors and their control systems, production of heavy water, health and safety instrumentation etc. to reprocessing of spent fuel and waste management. Presently, the country has four power reactors in operation of total capacity of 860 MW, two each at Tarapur Atomic Power Station (near Bombay) and Rajasthan Atomic Power Project (Kota, Rajasthan). The first unit of Madras Atomic Power Project with 235 MW capacity is the first indigenously designed nuclear power plant of the country and was expected to be commissioned during 1983. The second 235 MW unit of MAPP is expected to be commissioned in December 1984. Two units under Narora Atomic Power Project scheme are scheduled to be completed, one by 1986-87 and the other by 1987-88. India has four research reactors in operation at present. A fifth research reactor R-5 is a 100 MW high flux natural uranium, completely indigenous reactor. Scheduled to be commissioned in 1983-84, it will be used for production of isotopes for development of power reactor technology.

The attempt of the Department of Atomic Energy has been to achieve self-reliance and to reduce vulnerability in this strategic area. This has been made possible through work initiated at Tata Institute of Fundamental Research, the Atomic Minerals Division, and later principally at the Bhabha Atomic Research Centre and the Power Projects Division and various public sector undertakings. Related and associated areas of the use of radioisotopes for agriculture, medicine and industry and fall out relating to electronics and other high technologies have all been successfully pursued. A major achievement has been the successful, peaceful underground experiment carried out at Pokharan in May 1974. The objective of this was to study the catering effect of the explosion and to see how far it helped to crush rocks in the sub-structure of the earth. India's status as an advanced nation in the nuclear field was once again underlined when India was designated as member on its Board of Governors by the International Atomic Energy Agency for the 26th year in succession.

The R&D effort was oriented to achieving self-sufficiency in the exploitation of the potential for nuclear power generation and applications for national development and is accordingly directed to the development of power reactor systems and applications of radioisotopes in industry, agriculture and medicine.

TRANSPORT & COMMUNICATIONS

Transport and communications represent an area of remarkable development in India. This has been possible as a result of import of technology to develop the industrial base on the one

hand, and development of an indigenous base for the development of imported technology on the other . The impact of these developments can be judged from the fact that India is now producing automobiles, railway engines and carriages, aircraft and naval ships. Along with it, it has also developed structures like roads, traffic signalling systems, bridges, airports, and docks to meet the requirements of these systems. Some of the expertise it has generated is being shared with other developing countries.

The focus now in this sector is to optimise the operational efficiency and quality of the existing systems, energy-saving and efforts related to materials structures. One of the interesting features in this area has been the indigenous development of such means of transport as rickshaws, auto-rickshaws, mechanised crafts, and river boats. These meet the needs of small scale industry and individual users.

In the area of telecommunications, India has now developed the necessary capability to manufacture her own sophisticated materials and equipment. In this respect, mention may be made of switching and transmission systems and creation of support facilities, e.g. telephone instruments, digital telephones, key telephones, and microwave and line systems. The major areas in the plan of Indian Telephone Industries relate to digital telephone subscriber apparatus and instrumentation, telemetres, RTs and powerline carrier communication systems and integrated communication systems.

India with its vast areas, many of which are inaccessible and rural areas which have been outside the pale of communication systems, poses a special problem. The problem is further compounded because of the vast linguistic and cultural differences of different areas. R&D activities are now being directed to develop the hardware for communications system to meet this need. Very interesting and successful experiments have been carried out by Space Application Centre (SAC) at Ahmedabad for communication to rural areas.

SPACE SCIENCE AND TECHNOLOGY

The principal objective of India's space programme has been to develop indigenous competence in designing and building sophisticated hardware involved in space technology, including rockets and satellites for scientific research and practical applications, the use of the systems for providing point-to-point communication, and the application of satellites for meteorology and for remote sensing of earth resources. During the last decade, substantial progress has been made in establishing a firm indigenous base for the development of space science and technology.

As a result, ISRO today has a family of indigenously developed rockets for probing the atmosphere to various heights with different instrumentation systems. The smallest of these, for example, the single stage RH-125, can lift a nominal 7 kg payload to a height of 10 km, whereas the two-stage RH-560 is capable of carrying a 100-kg payload to about 350 km. Another combination has an intermediate capability specially suited to meteorological purposes. Chaff and temperature sensors carried in this enable measurement of wind and temperature up to an altitude of 65 km. Hundreds of these were successfully launched during MONEX (Monsoon Experiment) programme.

The successful launch of the SLV-3 (generic name for the first generation launch vehicles developed by ISRO) on 18 July 1980 is a major landmark in the history of space technology development in the country; this was the second experimental flight known as SLV-3-E-02. The first experimental flight (SLV-3-E-01), which took place in 1979, was only partially successful. But the second experimental flight was quickly followed by what is called the first developmental flight (SLV-3-D-1) on 31 May 1981. And on 17 April 1983 the country witnessed yet another successful launch of the vehicle in the form of SLV-3-D-2. The three successful flights of SLV-3 (one experimental and two developmental) over a period of less than 3 years clearly establish the maturity of design and repeatability in fabrication of launch vehicles in the country. The SLV-3 is, however, only a precursor to the larger launch vehicles ISRO plans to deploy in the eighties, viz. the Augmented Satellite Launch Vehicle (ASLV), and the Polar Satellite Launch Vehicle (PSLV).

As a preparatory step in developing satellite technology, ISRO took the course of building a satellite containing scientific experiment and having it launched by Soviet Union. Thus the launch of Aryabhata, the first Indian satellite, in April 1975 marked an important step in building competence in satellite technology. With the experience gained in Aryabhata, it was decided to follow it with a remote sensing satellite. The result was Bhaskara, launched in June 1979, again from the USSR. Bhaskara was similar to Aryabhata in many respects; the main difference lay in the payload.

Bhaskara-II, launched in November 1981, continues to be operational. A total of over 2000 TV pictures have so far been taken using camera-2 on board Bhaskara-II, which continues to provide imageries. Operations involving the satellite microwave radiometer payload, tape recorders, data collection platforms, tracking and solar cell experiment are being continued.

These Rohini satellites (RS) have been launched into low earth orbit by India's own launch vehicle, viz. SLV-3. So far, three Rohini satellites have been orbited: the first one (RS-1) was

basically a payload which evaluated the performance of the fourth stage of the SLV-3; the second (RS-D1) carried a landmark sensor as its main payload; the third one, RS-D2, carries a two-band imagery system known as the SMART sensor, which will help develop methodology for identification and classification of various ground features like snow/cloud, water, vegetation, etc.

Yet another significant milestone is the successful launch of the Ariane Passenger Payload Experiment (APPLE), India's first experimental geostationary communication satellite. The APPLE has been successfully used to conduct experiments in communications, technology relating to domestic communications, radio networking, data relay, remote area communications, etc. Long before positioning India's own communication satellite in the geostationary orbit, an intensive experiment was conducted to assess the technological as well as sociological aspects of satellite TV communications. This was the SITE (Satellite Instructional Televisions Experiment) which ran from August 1975 for a year. For this purpose, a collaborative programme was organised between National Aeronautics and Space Administration (NASA) and ISRO. NASA's geostationary communication satellite ATS-6 was suitably positioned for re-broadcasting TV programmes to about 2400 far-flung villages in all Indian states, using programmes from Ahmedabad and Delhi. The object of this complex mass communication experiment was to demonstrate the use of direct broadcast of TV programmes for rural development in the fields of agriculture, health, family welfare, education and national integration.

Another major preparatory satellite communication experiment was the STEP (Satellite Telecommunications Experiments Project) that was conducted for two years from mid-1977. Using the Franco-German geostationary communication satellite, Symphone, the STEP established the feasibility of using satellites for domestic communication needs. Both SITE and STEP experiments provided a firm technological base in the country for application of satellite communication.

Originally envisaged as a twin-satellite system (INSAT-1A and INSAT-1B), this is a multipurpose operational system for: domestic telecommunications, meteorological earth observations, nationwide direct telecasting to rural communities, and radio and TV programme distribution for rebroadcasting/networking. Launched in April 1982, INSAT-1A was unfortunately 'lost' in September 1982 owing to a "complex interplay of unforeseen events and relatively minor spacecraft deficiencies each of which, under normal circumstances, was extremely unlikely to cause a catastrophe". The operating capability of the INSAT-1 system was restored by late 1983, with the launch of INSAT-1B, after incorporating modifications in the light of the findings of the INSAT-1A Fault Finding Committee.

ENVRIONMENT

The Government of India attaches great importance to the concept of achieving development in harmony with ecological considerations. As a result, a separate Department of Environment was set up in 1980. Several programmes for checking environmental pollution and deforestation and to deal with legislation, management etc. are now under way. The key areas receiving high priority are: environmental and ecological research, environmental impact assessment, monitoring of environmental quality, setting up of environmental information system, public awareness/training/field action programmes, restoration of fragile ecosystems, organisation of ecodevelopment camps, preparation of an inventory of ecological resources, soil and water conservation, forest conservation and afforestation, social forestry and economic and industrial plantations, energy plantations, drinking water supply and water supply and sanitation. To implement these programmes, efforts are under way to ensure the participation of governmental, non-governmental and voluntary agencies, and above all, the people's participation.

OCEANOGRAPHIC RESEARCH

India is a peninsula with an extensive coastline and its territory also includes island groups in the Indian Ocean. Oceanography therefore has an important role to play in the country's development. Oceanographic research and development has particularly grown for the last two decades with the setting up of the National Institute of Oceanography (NIO). The work of the Oil and Natural Gas Commission (ONGC) relating to off-shore hydrocarbons, studies by naval research groups and participation in major instrumental programmes like IIOE, GARP and MONEX has also played a big part.

Arrangements have been made to acquire an oceanographic research vessel (ORV) from the Federal Republic of Germany. A vessel for R&D work on living marine resources of the Indian ocean region is in the process of being acquired.

One of the major achievements in this area has been the exploration of polymetallic nodules in the Indian ocean. The R&D work in this area was initiated by the National Institute of Oceanography, Goa in 1977. The first sample was collected by the Indian research vessel Gaveshni from the Indian ocean in 1980. Testing work on the sample of nodules collected is under way in research laboratories.

Indian science has now developed considerable expertise and experience in various branches of geology, geophysics, oceanography, meteorology, astrophysics, space science and

communication, as described earlier, to take up detailed studies on the landmass of Antarctica and oceanographic studies in the surrounding areas. Keeping this in view, the Department of Ocean Develoipment has successfully organised three scientific expeditions to the South Indian Ocean and Antarctica during 1981-1983.

DEVELOPMENT OF LARGE SCALE PLANTS FOR INDUSTRY

Chemical industry is a mainstay of a number of industries and is indicative of the industrial evolution or development of the country. The capacities in India have been built on the basis of imported technology and its adaptation on development resulting from indigenous R&D and also based on indigenous research. The contributions are in the areas of both natural products chemistry and synthetic chemistry. Further, the contribution covers cottage, small scale as well as large scale heavy industry.

One of the major contributions of India has been in the area of dyestuffs, leading to the establishment of dye industry of reckoning in the world market. India has been able to establish inorganic fertiliser industry. A major effort has been made in researches in synthetic insecticides which have led to the development of indigenous technology for the manufacture of these insecticides, whose technology was first developed in Europe but, was not made available to India on profitable conditions. With regard to insecticides and pesticides mention may be made of monocrotophos with a production of 600 tons per annum, Diazinon, with a production of 250 tons per annum, and endosulfan. In the area of drugs, indigenous R&D has led to the development of drugs for malaria (primaqunine), leprosy (depsone), amoeobiasis, a number of diuretic drugs, antibacterial drugs, various products of penicillin and other antibiotics. Recently, an antiinflammatory drug Tomaril, which has no after effects, has been released and may soon be available in world market.

In coal technology - extraction and washing it to make it suitable for diverse purposes- India may rank third in the expertise and technologies developed in this area. With the oil crisis, coal has again regained its significant position as a basic raw material for the production of fertilisers, dyes, and chemicals and as a sources of energy. India's contributions in this field are considered substantial. Coal washeries have been established and a 2,700 tonnes per day low temperature carbonisation plant, based on indigenous design and locally fabricated components, has been established.

NATIONAL FACILITIES

A country which aims to develop technologically and industrially has to develop and provide certain basic facilities and infrastructure. India has developed over the years wide-ranging national facilities to meet highly sophisticated requirements. Mention in this connection may be made of physical and electronic and other standards, and national facilities for wind tunnels of various sizes, metal fatigue testing of aircraft, testing of aircraft models, materials development, etc. Similarly, computer facilities have been developed to meet the requirements of hardware as well as software. National facilities for instrument development for airborne surveys, for testing the earth's mantle, for air and water pollution, and for deep sea research and mining have been developed and a network of centres to make the most sophisticated equipment for research, and for maintenance and repair has been established.

The large-scale production of a wide variety of chemicals, of drugs and of preservatives in different types of food has necessiated the study and assessment of their effects in plant and animal life and on man. These tasks require complex and time-series experiments to know the effects on different generations. Necessary facilities have, therefore, been established to test and find remedies for occupational hazards as in handling of chemicals and industrial materials, in the use of insecticides in agriculture and additives and of preservatives in foods.

INTERNATIONAL COOPERATION

The spectacular growth of scientific knowledge has brought into focus the international character of science, as also the need for intensifying scientific cooperation. Because of the increasingly complex and highly expensive nature of modern scientific and technological research, it is being realised that countries can save valuable resources and time by sharing each other's experience in diverse fields of scientific endeavour. In the past, scientific contacts were essentially at individual level, or, in some cases, at institutional level and these were predominantly in the area of basic sciences. In recent times, there has been an increasing awareness amongst developed as well as developing countries that cooperation in science and technology could be better fostered through inter-governmental mechanisms, particularly if the application of science and technology is to bring about overall national development. As a result, there has been a spurt in the number of formal scientific and technological agreements entered into between different countries. India too has followed this approach. The philosophy behind the bilateral agreements is that the cooperating countries, which, in most cases, are in somewhat similar stages of development, are likely to profit from such cooperation on an equal partnership basis. The bilateral agreements have thus done away, to a significant extent, with the usual concept of unequal partnership, i.e. donor-recipient relationship, which often existed in past.

India has always welcomed and actively participated in any effort which was aimed at promoting international cooperation for the betterment of all people and for bringing together countries with diverse political ideologies, economic and social systems and geographic locations. India is fully aware of the possibility that bilateral and multilateral cooperation can contribute to her own economic development. With this in view, India has contributed effectively through different U.N. specialised agencies like UNESCO, FAO, WHO or other international agencies like International Atomic Energy Agency, etc. Participation of India has been in the formulation of policies and programmes as well as in implementing various programmes of science and technology. India has also been organising in large number, on behalf of these agencies, special training programmes, workshops, seminars and

conferences in specialised topics as well as such areas as science policy, problems of R&D management, etc.

The programme of international cooperation in science and technology in India is carried out in a variety of ways: bilateral agreements, exchange programmes, participation in international scientific unions and associations, technical cooperation programmes, etc. India has inter-governmental agreements or arrangements for cooperation in the field of science and technology with several countries. Most of these agreements have been made in the last decade. Most of these bilateral agreements provide for exchange of scientific and technical personnel, exchange of scientific information, execution of joint research projects, organisation of binational seminars and workshops, etc. Detailed programmes of cooperation, identifying areas of mutual relevance and benefit, have been drawn up with several countries in pursuance of the agreements. It is hoped that these agreements will help in developing close relationships between India and various countries--developing as well as developed--and would enable Indian scientists and their foreign counterparts to have a clearer understanding of each other's capabilities, resulting in the flow of useful scientific and technical information and documentation, the successful execution of joint projects, and the promotion of national self-reliance. Self-reliance and international cooperation are not mutually exclusive.

Apart from the inter-governmental agreements, national level scientific agencies, such as the Council of Scientific & Industrial Research and the Indian Council of Agricultural Research have cooperation agreements with their counterpart bodies in a number of countries. Finally, scientific bodies such as the Indian National Science Academy also have exchange programmes and cooperative activities with foreign societies, associations and academies. However, in this connection, it mut be emphasised that in India the desire for international collaboration with developed countries is aimed at obtaining sophisticated technologies, which are considered essential for national development. As part of the national programme of satisfying basic needs, which have been given priority, India is anxious to use all available technologies most appropriate for national development. The available science and technology infrastructure is fairly adequate for satisfying most of the basic needs in the area of literacy, adult education, rural water supply, rural electrification, roads, etc. and only a more coordinated approach is called for. But while outlining cooperative efforts in the areas of sophisticated technologies, which are nationally required in the development process, mention should also be made of some difficulties encountered in obtaining the necessary materials, equipment and technology.

Non-governmental organisations, international unions of specialised subjects, academies, and scientific and technical societies are platforms where scientists and technologists meet and discuss problems in an academic and free atmosphere. Indian scientists by virtue of their eminence in various fields of science have been playing a major role in the deliberations of these organisations in various ways. Many of the Indians hold respectable positions in many such organisations. Special organisations like World Federation of Scientific Workers and Pugwash Movement have been founded to meet scientific needs. Indian scientists have played a major role in the creation of such organisations and in the promotion of their activities.

In 1964, India under the leadership of Nehru, who passed away, only a few months later, had invited scientists from developing countries of Asia and Africa to participate in a national conference of scientists to discuss the role of science and technology in national development. This was followed by a major conference in 1966 on the topic of collaboration amongst the developing countries of Asia, Africa and Latin America in the field of science and technology. These two conferences initiated the movement of collaboration amongst the developing countries. India's policy under Technical Cooperation among Developing Countries(TCDC), as enunciated was clearly stated in her national paper for the United Nations Conference on Science and Technology for Development (Vienna, 1979).

The UNCSTD recorded:

High priority has been given by India to cooperation among developing countries in the implementation of its international scientific and technological cooperation programmes. This becomes all the more important when developing countries belonging to a particular region or sub-region have similar or common problems, which could be more easily solved through regional or sub-regional cooperation. As a developing country, India has made substantial progress in the fields of science and technology and has used the concept of socio-economic development through application of science and technology. Through the forums of the United Nations and its specialised agencies and those of the non-aligned and Commonwealth countries, India has volunteered to share its experience with other developing countries on a reciprocal basis. For example, at the multi-lateral level there is a proposal to set up a project development facility to promote the use of technical skills and know-how available among Non-Aligned Countries through the preparation of feasibility studies and project reports and for encouraging the use of equipment available in these countries for executing projects and programmes. India has taken a keen interest in the preparatory work for the setting up of this facility.

Emphasis is laid on the following factors while formulating and implementing partnership arrangements with other developing countries:

(a) Areas of common interest are carefully identified, keeping in view their relevance in the national contexts of the two countries. Careful stock is taken of the available physical facilities and skilled manpower so that different aspects of the problem can be tackled by the two countries on a complementary basis. This results in a better appreciation of the scientific and technological capabilities as well as in the speedier attainment of the desired objectives. This also enhances the self-reliance and self-confidence of scientists in the two countries.

(b) Where trained manpower, in the form of scientists and technicains, is lacking, efforts are made to provide training facilities either at regular institutes of higher learning, training organisations or in some cases, through short-term or long-term attachment to research laboratories. Such a programme is usually time-bound and enables the cooperating country to become self-reliant in the science and technology endeavour. The provision of this facility is done mainly through mutually agreed upon technical and economic cooperation programmes.

(c) Gaps in technical expertise are identified in close consultation with the country concerned and efforts are made to make available the services of specialists on a bilateral basis or under the auspices of the UN and its specialised agencies. Technical consultancy services, where desired by the country concerned, are also made available, apart from exchange of scientific and technological information and documentation.

(d) Exchange of information and experience on appropriate technologies, selection crieteria and assistance in technology adaptation and transfer.

(e) Cooperation in the establishment of consultation and design engineering organisations in other developing countries.

(f) Sharing of India's experience in the organisation of science and technology and on science policy and planning.

Careful planning, as suggested above, is intended to reduce the scientific and technological dependence of developing countries on external assistance through the building up of their own scientific expertise and physical facilities. It would also be necessary to overcome attitudinal barriers to the promotions of cooperation among developing countries. These are often reflected when

developing countries obtain the services of experts from developed countries for the planning and implementation of various projects, even though such expertise is available in other developing countries.

INDIA'S JOINT VENTURES ABROAD

Joint ventures are an important instrument for sharing technology and for economic cooperation between the developing countries. India has acquired through the process of planned economic growth as well as emphasis on scientific and technical education, research and development a sound base of modern technology. She has gained experience and expertise in several fields of modern technology as well as in the management of industry. She is in a position to share the fruits of her experience with other developing countries and thus assist them in the process of their economic advancement. The technology developed by India has found wide acceptability in the developing countries. Already, a large number of joint ventures based on Indian technology and, in many cases capital participation, are operating in a number of developing countries. Some joint ventures have been set up even in the developed countries.

By 31 March 1983, there were 228 effective joint venture proposals, out of which 140 joint ventures were in production or operation and 88 proposals were under various stages of implementation. Region-wise, the largest number of Indian joint ventures are located in the neighbouring countries of Asia (77) followed by Africa (22). Indian joint ventures currently in operation are dispersed over 27 countries. A little over 80 per cent of them are concented in 10 countries.

The Indian joint ventures abroad encompass a very wide spectrum of industrial products ranging from consumer goods to heavy engineering products. The items of manufacture by Indian joint ventures cover textiles, light engineering goods, iron and steel products, automobile ancillaries, machine tools, hand tools, instruments, commercial vehicles, scooters, heavy engineering items, non-ferrous metal products, chemicals and pharmaceuticals, plastic products, cement, glass and glassware, pulp and paper, sugar, processed foods, confectionary, soft drinks, oilseeds crushing and refining, hardboards, mosaic tiles, rubber products, leather products, enamelled wire, electronics, hotels and restaurants, consultancy and constrution projects, and the like. Engineering, chemical and pharmaceutical industries account for the highest proportion, followed by construction, trade and consultancy.

TECHNICAL CONSULTANCY

Along with the all-round development of Indian manufacturing capability in different industrial sectors, the standard of technical consultancy services in India has attained a new high. A large number of consulting engineering firms are already rendering project engineering and technical consultancy services in foreign countries, from the stage of concepts to the act of commissioning, providing appropriate know-how and design engineering. The range of consultancy services available includes, among others, integrated consultancy services spanning the entire spectrum of services such as development planning, studies of economic environment, socio-economic surveys, project identification, preparation of project profiles, market research, techno-economic feasibility studies, turn-key assignment, engineering of the project commissioning and initial operations, management, manpower development, training services, procurement and evaluation of plant and equipment.

PROJECT EXPORT

Project export is another form of transfer of technology. Indian enterprises have successfully completed a large number of projects in diverse fields in several developing countries, such as Libya, Kuwait, UAE, Iraq, Nigeria, Tanzania, Mauritius, Thailand and Malaysia.

Indian projects set up in other countries include power plants, sugar mills, textile, cement, paper and pulp mills, metallurgical and engineering industries, chemical and pharmaceutical plants etc. The services rendered by Indian companies include project identification, planning, selection, supply, erection and commissioning of equipment, training of local personnel, and in many cases running the project for a specified duration of time. These projects have been set up by Indian enterprises in the face of stiff international competition. Many of them have been financed by international financial institutions like the World Bank and Asian Development Bank.

COLLABORATION WITH INTERNATIONAL CONTRACTORS

European, American and Japanese project contractors and equipment suppliers who bid for projects in developing countries in West Asia, East Asia, Africa etc. face a shortage of technically skilled and managerial personnel. The high cost of professional services works out, in some cases, uneconomic to contain the overall project costs.

Sometimes because of non-availability of facilities and uncongenial climatic conditions in developing countries, international prime contractors face problems for deployment of proper project personnel.

In some cases, supply of plant and equipment from European, American and Japanese sources works out uneconomical as compared to supply of the same from Indian sources.

The situation has convinced many of the American, European and Japanese contractors to entrust segments of their-third country projects to India. A long-term agreement has been entered into by a renowned public sector undertaking in India with a well-known British group for working together in projects in third countries. Another public sector undertaking in India has been collaborating, in some bids, with General Electric Company of the USA, Siemens of FRG and GEC of the UK. A British company is collaborating with a firm in South India for manufacture of hosiery in Dubai.

A few private sector companies have already entered into some tie-up arrangements and signed memorandums of understanding with leading project contractors and equipment suppliers in Europe for joint tendering in projects in third countries and in fact are quoting together for such projects.

INDIAN TECHNICAL AND ECONOMIC COOPERATION PROGRAMME (ITEC)

In view of India's relatively diversified industrial base, advanced technological capability and availability of skilled manpower, she has been sharing her accumulated experience since 1964 under ITEC Programme with other developing countries.

The ITEC Programme includes: (a) provision of training facilities to nationals of developing countries in India, (b) deputation of Indian experts abroad, (c) gifts of machinery and equipment, (d) assistance for conducting feasibility studies, and (e) undertaking of specific projects.

The technical assistance and other programmes executed under ITEC programme have been appreciated by the recipient countries. Extensive assistance programmes have been undertaken in Sri Lanka, Burma, Afghanistan, Vietnam, Mauritius, Tanzania and Fiji. Specialised training programmes are made available for personnel from developing countries on the basis of applications from developing countries, discussions in meetings of joint commissions wherever applicable, and through the recommendations of Indian missions abroad. In allocation of assistance to various countries, special consideration is given to the least developed countries.

In the area of civil aviation, the training is imparted by the Department of Civil Aviation, which covers flying, aircraft

maintenance, engineering, aeronautical, telecommunication, navigational aids, air traffic control and fire fighting. The training is imparted through regular courses conducted at the Civil Aviation Training Centre, Allahabad. In addition, field training is given at various locations such as aerodromes, air traffic control centres, wireless transmitting and receiving stations and navigational units. The Fire Services Training Centre, Calcutta, gives training in aerodrome fire-fighting service. Various flying and gliding clubs are also used for training courses.

In the field of meteorology, the training is imparted through the India Meteorological Department. It has also currently organised a training course for meteorological personnel of Nigeria and Kenya at its Agricultural Meteorology Division at Pune.

Apart from Nigeria and Kenya, the Meteorological Department has been affording training facilities to various countries in the Afro-Asian region and the Arab world.

Requests are also received from the World Meteorological Organization for training of nominees of various governments under the United Nations Development Programme(UNDP).

The Indian experience gained in the field application of modern technology in agriculture has proved useful in the developing countries of Asia and Africa. The Central Plant Protection Training Institute has trained a number of personnel from South East Asia. It is expected to become shortly a regional centre for plant protection training activities catering to the needs of not only India but also other developing countries. India has assisted Sri Lanka and Vietnam in their cattle and buffalo development programmes. A herd of well-known Gir cattle and Surti buffaloes was given to Sri Lanka for establishing farms, while the Indian Council of Agricultural Research is helping Vietnam to set up a buffalo research institute. India has assisted Sri Lanka, Bhutan and Vietnam in developing their fodder resources as part of the livestock development programme. In addition to technical expertise, seed material of high yielding varieties of fodder crops were supplied to them. Technical expertise has also been provided to a few other countries under the aegis of FAO sponsored schemes. The Indian Grassland and Fodder Research Institute at Jhansi is being considered an international training centre on the tropical fodder grassland by the FAO; the institute conducts comprehensive training courses on all facets of grassland and fodder production. India is in a position to undertake overseas projects in dairying on a turnkey basis. The National Dairy Development Board has assisted several countries in the preparation of feasibility studies and project appraisals. These include Mauritius, Sudan, the Philippines, Indonesia, Bhutan and Tanzania. Personnel from several developing countries like Nigeria, Thailand, Sri Lanka, Tanzania, Nepal and the Philippines

have also been trained by the Board in collaboration with and support from agencies like UNICEF, DANIDA, FAO, etc. Training facilities in poultry farming at Hassarghatta, near Bangalore, have been availed of by participants from other developing countries like Bangladesh, Papua New Guinea and Sri Lanka. Poultry experts in the Department of Agriculture and Cooperation, Ministry of Agriculture, have prepared special projects for poultry development in Bhutan. India has also been sending professional foresters to help in the formulation and implementation of forestry programmes of various developing countries either under bilateral or multilateral aid programmes.

In the field of health, India has been offering places to nationals from developing countries in institutions which train nurses, doctors and specialists in almost all fields of medicine. India has also been supplying a considerable variety of medical equipment to other developing countries.

In the field of higher education and related activities also, India cooperates with a number of developing countries in Asia. Some of this cooperation has been on a bilateral basis and some under the auspices of international organisations like UNESCO. In the field of higher education, for instance, India has organised a number of international post-graduate courses covering subjects like chemistry, physiology, micro-palaeontology, himalayan geology, hydrology, etc. Other courses covering topics like tropical nutrition, physical engineering, solid state physics, marine geology, etc. are in advance stage of planning.

India has deputed experts to other developing countries in such diverse fields as education, planning, dairy development, small scale industries, engineering and medicine. The following tables show the distribution of the Indian experts serving in other countries under ITEC and bilateral assignments for the period 1970 to 1981.

In the field of science and technology, India was one of the countries that took the initiative to bring into existence a Regional Centre for Technology Transfer for providing the much needed assitance to the countries of the ESCAP region in the field of transfer of technology. This Centre, located at Bangalore, assists various national centres in a variety of operations related to technology transfer, like identifying technical need for a variety of economic activities, obtaining need-based information on alternative sources of technology, assisting in evaluation and selection of technologies and unpackaging of imported technology, negotiating for the best possible terms in the import of technology, and generation of indigenous technology etc.

With the explosion of scientific knowledge and increasing complexities of technological investigations requiring large inputs, it has been realised that it would be very advantageous to pool

Indian experts serving in other countries on ITEC Assignments
Statement showing break-up of Experts selected year-wise
and category-wise for I.T.E.C. assignment from
January 1970 to December 1981.

Year	Doctors	Nurses & other para-medical staff	Prof./ Teachers Education Officers	Engg, Arch. Geol. and other tech. experts	Finan. Experts Accoun-tants etc.	Econom-ist and ticians	Misc. experts Statis-	Total
1970	15	02	025	003	-	-	008	053
1971	01	01	013	010	08	01	010	044
1972	05	16	006	005	02	-	009	043
1973	02	02	016	046	01	-	020	087
1974	06	03	018	027	03	-	007	064
1975	08	01	006	024	04	05	021	069
1976	12	-	013	026	05	01	018	075
1977	07	03	009	016	01	01	009	046
1978	01	02	019	019	02	02	009	054
1979	03	-	024	012	03	01	029	072
1980	04	01	011	027	01	04	024	072
1981	03	-	007	027	02	-	009	048
TOTAL	67	31	167	242	32	15	173	727

Indian experts serving in other countries on Bilateral Assignments
Statement showing break-up of Experts selected year-wise and category-wise for bilateral assignments from January 1970 to December 1981

Year	Doctors	Nurses & other para-medical staff	Prof./ Teachers Education Officers	Engg, Arch. Geol. and other tech. experts	Finan. Experts Accoun-tants etc.	Econom-ist and Statis-ticians	Misc. experts	Total
1970	0012	0004	0024	0074	030	10	016	00170
1971	0030	0004	0089	0076	025	02	025	00251
1972	0117	0281	0060	0133	043	03	041	00678
1973	0119	0098	0249	0253	038	01	046	00801
1974	0165	0184	0163	0530	042	04	070	01158
1975	1369	0218	0335	0214	016	03	161	02316.
1976	0321	0152	0146	0315	012	16	021	00983
1977	0861	0286	0319	0433	111	02	019	02031
1978	0612	0001	0085	0344	059	-	045	01146
1979	0327	-	0319	0378	070	02	042	01138
1980	0142	0011	0453	0411	054	06	020	01097
1981	0083	-	0366	0499	031	01	-	00980
TOTAL	4158	1236	2608	3660	531	50	506	12749

resources available in different countries to derive maximum benefits from research and development. In addition, bilateral cooperation agreements in science and technology have also been used to promote exchange programmes, joint seminars and workshops, joint research programmes etc. with many developing and Non-Aligned Countries.

India is collaborating with Burma in the setting up of several pilot plants relating to infrastructural facilities for workshops, straw board/filter paper, gamma irradiator, manganese dioxide, mentha cultivation, etc. Sixteen pilot plants involving an investment of over Rs.2 crores are being implemented. It is expected that the implementation of such plants will enable Burma to use technologies which are most appropriate to her needs based on available natural resources.

This brief account shows India's open-door policy as well as her role as recipient as well as donor to the world of science and technology. As ever, always India has been at the crossroads of civilisations and cultures, receiving from them, and enriching them, and this role she continues to this day.

EPILOGUE

Has the development of science and technology become an end in itself? Has it contributed to national development? Whom has it benefited? These are a few of the searching questions that face the nation which is due to launch its seventh Socio-economic development plan. A bird's eye view of the preceding chapters, gives some idea of the scale and range of S&T activities. Also discernible is how S&T developments have, affected the lifes of people of this country.

The social transformation and cultural revival of a country, which had undergone nearly two hundred years of colonial rule, and which underwent a most traumatic experience of division and large-scale transfer of population, is not an easy task. This is especially so, when the country is poor and its people suffer not only from poverty and illiteracy but also from fatalism, inactivity and lack of initiative.

The last thirty-six years, a mere moment on the scale of history, have brought about a major change. One is struck with the extent of developments which have taken place during this short span. One could almost reach any part of the country within hours by a fairly efficient air service, within 24-30 hours by rail (before independence it would take 45-60 hours) or by motor transport. One could dial any part of the country, as far as the major towns are concerned, directly, or connect otherwise and talk on the telephone - services which were almost non-existent, especially the ones like, telex and computers. Whatever be the contemporary developments elsewhere in the world, no matter as to their sophistication or complexity, India does find herself on such a map, as a growing and developing country, advancing with rapid strides, catching up with the advanced countries.

The green revolution has doubtless brought prosperity to the countryside, which has undergone a major transformation in recent years. Mechanisation of agriculture and the abundance of production have not only brought a new sense of confidence to the present but have changed his outlook and attitude considerably. The introduction of television and the transistor has also changed the horizons and cultural vistas, and has taken the countryside into a new dimension of change and development. Old sleepy villages have now become a thing of the past. With satellite communication becoming a reality, the change would be even more evident. There were hardly any industries at the time of Independence, and such as were, managed by Europeans. Today

there are a host of highly sophisticated industries and all of them are not only managed by Indians but their technology has been created indigenously.

New sophisticated industries have given a wide range of new materials and consumer goods to the people, who have in turn acquired new skills and techniques and developed a new confidence - a confidence that our country is as good as any in the world and is capable of achieving the best.

Yet, in these very changes are a reminder to us that development should not be for only those who are affluent, that there is stark inequality, and that gains from development have not reached the people whom they ought to have reached. That illiteracy and outmoded concepts and intellectual attitudes still dominate the minds of people, creating tensions, problems, and very often misery, is the negative side of development. To eradicate all these is a major task, much more difficult and much more complex. Would it be possible for India to undertake such a task in a big way? And to achieve progress in a short time? Only time can tell, but the indications, however, are that not only in such a task possible but that the objective would be achieved in a substantial way in a shorter time than most people expect. Who could have thought at the time of independence that India would, in a small time span of 30 years, be building up capability to produce atomic energy or to fire rockets into space and fix telecommunication satellites?

As a consequence of being deprived of the benefits of earlier developments, people since independence appear to have developed an aggressiveness and covetousness, which is not only not healthy but has also affected the fabric of life of the society, which in turn may be detrimental to future progress. It takes time to make people believe in future and make them realise that unless there is equality and sharing of gains of development their very future and personal gains are likely to be jeopardised.

Life is short, art is long. The tasks before humanity are too many and too great, the means at its disposal too few. Life span is too short, and in this little time we only see a little of the immediate, the tangled chaotic intertwined mass. And we do not realise that what appears to us as an ebb, is the ebb of an advancing wave. We continue to see the shortcomings, the limitations and the confusion. The achievements in relation to our aspirations are lost in this maze. It is only when we look over a period we begin to realise the road we have covered, where we have reached and what we have achieved. It is this lookback which gives us hope and sustenance and we begin to see the future with some hope and confidence - and start work anew with greater zeal and vigour.

India is at the moment in this stage of transition.

LIST OF ORGANISATIONS

COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH

1. Central Building Reseach Institute,
Roorkee - 247667.

2. Central Drug Research Institute,
Chattar Manzil Palace,
Post Box No. 173,
Lucknow - 226001.

3. Central Electrochemical Research Institute,
CECRI Nagar,
Karaikudi - 623006.

4. Central Electronics Engineering Research Institute,
Pilani - 333031.

5. Central Food Technological Research Institute
Mysore - 570013.

6. Central Fuel Research Institute,
P.O. FRI,
Dhanbad - 828108.

7. Central Glass and Ceramic Research Institute,
P.O. Jadavpur University,
Calcutta - 700032.

8. Central Institute of Medicinal & Aromatic Plants,
Post Bag No. 1,
P.O. Ram Sagar Misra Nagar,
Lucknow - 226016.

9. Central Leather Research Institute,
Adyar, Madras - 600020.

10. Central Mechanical Engineering Research Institute,
Mahatma Gandhi Avenue,
Durgapur - 713209.

11. Central Mining Research Station,
Barwa Road,
Dhanbad - 826001.

12. Central Road Research Institute,
P.O. CRRI,
New Delhi - 110020.

13. Central Salt and Marine Chemicals Research Institute,
Gijubhai Badeka Marg,
Bhavnagar - 364002.

14. Central Scientific Instruments Organisation,
Sector 30,
Chandigarh - 160020.

15. Centre for Cellular and Molecular Biology,
Regional Research Laboratory Campus,
Uppal Road,
Hyderabad - 500007.

16. CSIR Centre for Biochemicals,
VP Chest Institute Building,
University Campus,
Delhi - 110007.

17. CSIR Complex Cochin,
Industrial Estate,
P.O. Pappanamcode,
Trivandrum - 695018.

18. CSIR Madras Complex,
Taramani, TTTI Post Office,
Madras - 600113.

19. Electrical Research and Development Association, P.B.No. 760, Makarpura, Industrial Estate, P.O. Vadodara - 390010.

20. Indian Institute of Chemical Biology, 4, Raja S.C . Mullick Road, Jadavpur, Calcutta - 700032.

21. Indian Institute of Petroleum, P.O. I.I.P., Dehradun - 248005.

22. Indian National Scientific Documentation Centre, 14, Satsang Vihar Marg, Special Institutional Area, New Delhi - 110067.

23. Institute of Microbial Technology, House No. 1383, Sector 33 C, Chandigarh - 160031.

24. Industrial Toxicology Research Centre, P.O. No. 80, Mahatma Gandhi Marg, Lucknow - 226001.

25. National Aeronautical Laboratory, Post Bag No. 1779, Bangalore - 560017.

26. National Botanical Research Institute, Rana Pratap Marg, Lucknow - 226001.

27. National Chemical Laboratory, Pune - 411008.

28. National Environmental Engineering Research Institute, Nehru Marg, Nagpur - 440020.

29. National Geophysical Research Institute, Uppal Road, Hyderabad - 500007.

30. National Institute of Oceanography, Dona Paula - 403004. Goa

31. National Institute of Science, Technology and Development Studies, Hillside Road, New Delhi - 110012.

32. National Metallurgical Laboratory, P.O. Burmamines Jamshedpur - 831007.

33. National Physical Laboratory, Hillside Road, New Delhi - 110012.

34. Publications and Information Directorate, Hillside Road, New Delhi - 110012.

35. Regional Research Laboratory, Library Building (Ground Floor), University of Bhopal, Bhopal - 462026.

36. Regional Research Laboratory, Bhubaneswar - 751013.

37. Regional Research Laboratory, Uppal Road, Hyderabad - 500007.

38. Regional Research Laboratory, Canal Road, Jammu - Tawi - 180001.

39. Regional Research Laboratory, Jorhat - 785006 (ASSAM).

40. Regional Research Laboratory, Industrial Estate, P.O. Pappanamcode, Trivandrum - 695019.

41. Structural Engineering Research Centre,
CSIR Complex,
TTTI - Taramani (Post)
Madras - 600113.

42. Structural Engineering Research Centre,
Roorkee - 247672.

43. Tocklai Experimental Station,
Tea Research Association,
Jorhat - 785008.(ASSAM).

44. CSIR Complex
Palampur (H.P.)

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

1. All India Coordinated Rice Improvemenet Project,
Rajendra Nagar,
Hyderabad - 500030.

2. All India Coordinated Research Project on Dryland Agriculture,
2-2-58/60, Amberpet,
Hyderabad - 500013.

3. Central Agricultural Research Institute,
For Andaman & Nicobar,
group of Islands,
Port Blair - 744101.

4. Central Avian Research Institute,
Izatnagar - 243122.

5. Central Arid Zone Research Institute,
Jodhpur - 342001.

6. Central Inland Fisheries Research Institute,
Barrackpore - 743101.

7. Central Institute of Agriculture,
Shri Guru Teg Bahadur Complex,
Addl.'A' Block, New Market,
T.T. Nagar, Bhopal -462003.

8. Central Institute for Cotton Research,
95, Pushpa Kunj,
Canal Road,
New Ramdaspeth,
Nagpur - 440010.

9. Central Institute of Fisheries Education,
Post Box No. 7392,
Kakori camp, Jaiprakash Road,
Bombay - 400061.

10. Central Institute of Fisheries Technology,
P.O. Mastsyapuri,
Cochin - 682029.

11. Central Marine Fisheries Research Institute,
P.O.No. 1912, Cochin -682018.

12. Central Plantation Crops Research Institute,
Post Kudlu,
Kasargod - 675017.

13. Central Rice Research Institute,
Simla - 171001.

14. Central Rice Research Institute,
Cuttack -753006.

15. Central Sheep & Wool Research Institute,
P.O. Avikanagar -304501, Via,
Jaipur.

16. Central Soil Salinity Research Institute,
Karnal - 132001.

17. Central Soil & Water Conservation Research & Training Institute,
218, Kaulagarh Road,
Dehradun - 248195.

18. Central Tobacco Research Institute,
Rajahmundry - 533104.

19. Central Tuber Crops Research Institute,
Sreekariyam,
Trivandrum-695017.

20. Cotton Technological Research Laboratory,
Adenwala Road,
Matunga,
Bombay-400019.

21. Directorate of Oilseeds Research,
'D' Block, College of Agriculture,
Rajendranagar,
Hyderabad-500030.

22 Indian Agricultural Research Institute,
Hillside Road, Pusa,
New Delhi-110012.

23. Indian Agricultural Statistics Research Institute,
Library Avenue,
New Delhi-110012.

24. ICAR Research Complex for North Eastern Hills Region,
Cadar Lodge, Jawai Road,
Shillong-793003.

25. Indian Grassland & Fodder Research Institute,
Gwalior Jhansi Road,
Jhansi-234001.

26. Indian Institute of Horticultural Research,
255, Upper Palace Orchards,
Bangalore-560080.

27. Indian Institutue of Sugarcane Research,
Post Office Dilkhusha,
Lucknow-226002.

28. Indian Lac Research Institute,
P.O. Namkum,
Ranchi-834010.

29. Indian Veterinary Research Institute,
Izatnagar-243122.

30. Jute Agricultural Research Institute,
24-Paraganas, P.O.
Barrackpore-743101.

31. Jute Technological Research Laboratory,
12, Regent Park,
Calcutta-700040.

32. National Academy for Agricultural Research Management,
Rajendranagar,
Hyderabad-500030.

33. National Bureau of Plant Genetic Research,
F.C.I. Building,
C.T.O. Complex,
Pusa,
New Delhi-110012.

34. National Bureau of Soil Survey and Land Use Planning,
Seminary Hills,
Nagpur-440006.

35. National Dairy Research Institute,
Karnal-132001.

36. National Goat Research Institute,
Makhdoom, P.O.,Farah,
District, Mathura-281122.

37. National Research Centre for Groundnut,
Maharashi Dayanand Farm,
Gujarat Agricultural University,
Campus, Junagarh.

38. Sugarcane Breeding Institute,
Lawley Road,
Coimbatore-641007.

39. Vivekanands Parvitya Krishi Anusandhan Shala,
Almora-263601.

INDIAN COUNCIL OF MEDICAL RESEARCH

PERMANENT INSTITUTES/CENTRES

1. National Institute of Nutrition, Jamai-Osmania, Hyderabad-500007.
2. National Institute of Virology, 20-A, Dr. Ambedkar Road, Pune-411001.
3. Institute of Research in Reproduction, Jehangir Merwanji Street, Parel, Bombay-400012.
4. Tuberculosis Research Centre, Spur Tank Road, Chetput, Madras-600031.
5. Institute of Immunohematology, (Formerly Blood Group Reference Centre), Seth G.S. Medical College, Parel, Bombay-400012.
6. National Institute of Cholera and Enteric Diseases, 3, Dr. M. Ishaque Road, (Kyd Street), Calcutta-700016.
7. Institute of Pathology, Safdarjang Hospital, New Delhi-110029.
8. National Institute of Occupational Health, Meghani Nagar, Ahmedabad-380016.
9. Vector Control Research Centre, Indira Nagar, Gorimedu, Pondicherry-605006.
10. Laboratory Animal Information Service, National Institute of Nutrition, Jamai-Osmania, Hyderabad-500007.
11. Food and Drug Toxicology Research Centre, National Institute of Nutrition, Jamai-Osmania, Hyderabad-500007.
12. Central Jalma Institute for Leprosy, Tajganj, Agra-282001.
13. Malaria Research Centre, 22, Sham Nath Marg, Delhi-110054.
14. Institute for Research & Medical Statistics, ICMR Campus, Ansari Nagar, New Delhi-110029.
15. Institute for Research in Medical Statistics, Sathyamurthi Road, Chetput, Madras-600031.
16. Cytology Research Centre, Maulana Azad Medical College, New Delhi-110002.
17. Enterovirus Research Centre, Haffkine Institute, Parel, Bombay - 400012.
18. Rejendra Memorial Research Institute for Medical Sciences, Agam Kuan, Patna-800007.

REGIONAL MEDICAL RESEARCH CENTRES

1. Regional Medical Research Centre, Belgaum.
2. Regional Medical Research Centre, Bhubaneswar.
3. Regional Medical Research Centre, Dibrugarh.
4. Regional Medical Research Centre, Jabalpur.
5. Regional Medical Research Centre, Jaipur.
6. Regional Medical Research Centre, Port Blair.

CENTRES FOR ADVANCED RESEARCH

1. Centre for Advanced Research in Reproductive Biology, Indian Institute of Science, Bangalore-560012.
2. Centre for Advanced Research in Genetics and Cell Biology, Indian Institute of Science, Bangalore-560012.
3. Centre for Advanced Research in Neuropharmacology, K.G. Medical College, Lucknow-226003.
4. Centre for Advanced Research in Virology, Christian Medical College, Vellore-632004.
5. Centre for Advanced Research in Community, Psychiatry, National Institute of Mental Health and Neurosciences, Bangalore-560029.
6. Centre for Advanced Research in Haematology Postgraduate Institute of Medical Education and Research, Chandigarh-160012.
7. Centre for Advanced Research in Neurobiochemistry, Osmania Medical College, Hyderabad-560007.

DEFENCE RESEARCH & DEVELOPMENT ORGANISATION

1. Armament Research & Development Establishment Pashan, Pune-411021.
2. Explosives Research & Development Laboratory, Pashan, Pune-411021.
3. Instruments Research & Development Establishment, Raipur, Dehra Dun-248008.
4. Terminal Ballistics Research Laboratory, Sector 30, Chandigarh-160020.
5. Proof & Experimental Establishment, Balasore-756001.
6. Defence Research & Development Laboraotry, Phisalbanda, P.O. DMRL, Hyderabad-500258.

7. Electronics & Radar Development Establishment,
P.O. Box No.-5108,
High Grounds,
Bangalore-560001.

8. Solid State Physics Laboratory,
Lucknow Road;
Timar pur,
Delhi-110007.

9. Defence Electronics Research Laboratory,
Chandrayanagutta Lines,
Hyderabad-500005.

10. Defence Electronics Applications Laboratory,
Sunder Wala Camp,
P.O. Raipur,
Dehra Dun-248008.

11. Research & Development Establishment,
(Engineers) Pioneer Lines-Dighi
Pune-411015.

12. Snow & Avalanche Study Establishment,
C/o 56 APO.

13. Defence Institute of Fire Research,
Probyn Road,
Delhi-110007.

14. Combat Vehicles Research & Development Establishment
Avadi
Madras - 600054.

15. Vehicles Research & Development Establishment
Ahmednagar-414001.

16. Aeronautical Development Establishment,
Jeewan Bhimanagar,
Bangalore-560075.

17. Gas Turbine Research Establishment,
Suranjan Das Road,
P.B.No: 1777,
Bangalore -560075.

18. Centre for Aeronautical Systems Studies and Analysis
263, Mahalakshmi Layout,
Bangalore - 560010.

19. Defence Bio-Engineering and Electro Medical Laboratory
Indira Nagar,
Bangalore-560038.

20. Naval Chemical & Metallurigical Laboratory,
Naval Dockyard,
Bombay-400001.

21. Naval Physical & Oceanographic Laboratory,
Naval Base,
Cochin-682002.

22. Naval Science & Technological Laboratory,
Vishakhapatnam.

23. Defence Science Centre,
Metcalfe House,
Delhi-110054.

24. Defence Materials & Stores Research & Development Establishment,
P.B.No. 320,
Kanpur - 208004.

25. Defence Metallurgical Research Laboraotory,
P.O. DMRL,
Hyderabad-500258.

26. Defence Laboratory,
Post Box No. 136,
Jodhpur.

27. Aerial Delivery Research & Development Establishment
P.B. No: 51,
Station Road,
Agra Cantt.

28. Defence Research & Development Establishment,
Tansen Road,
Gwalior-474002.

STIPO

29. Defence Food Research Laboratory, Jyothi Nagar, Myusore-570010.

30. Defence Research Laboratory, Post Box No. 2, Tezpur (ASSAM) - 784001.

31. Field Research Laboratory, C/o 56 APO.

32. Defence Scientific Information and Documentation Centre. Metcalfe House, Delhi-110054.

33. Institute of Nuclear Medicine and Allied Sciences, Probyn Road, Delhi-110007.

34. Defence Institute of Physiology and Allied Sciences Delhi Cantt - 110010.

35. Agricultural Research Unit, Almora.

36. Defence Research & Development Unit, S-2/2 Commissariate Road, Hastings, Calcutta-700022.

37. Institute of Armament Technology, Singabad Road, Girinagar, Pune-411025.

38. Defence Institute of Work Study, Landour Cantt (Mussoorie)-248179.

39. Institute for Systems Studies & Analysis, (ISSA), Metcalfe House, Delhi-110054.

40. Defence Terrain Research Laboratory, Metcalfe House, Delhi-110054.

41. Directorate of Psychological Research, West Block No.8, Wing No. 1, R.K. Puram, New Delhi-110022.

DEPARTMENT OF ATOMIC ENERGY

R & D UNITS

1. Bhabha Atomic Research Centre Chhatrapati Shivaji Marg, Bombay - 400085.

2. Reactor Research Centre Kalpakkam, Tamil Nadu.

3. Gauribidanur Seismic Station Bangalore.

4. High Altitude Research Laboratory Gulmarg, Kashmir.

5. Nuclear Research Laboratory Srinagar.

6. Variable Energy Cyclotron Centre Bidhan Nagar, Calcutta - 700064.

POWER SECTOR

1. Atomic Minerals Division 1-11-1200 Begumpet Hyderabad - 500016.

2. Nuclear Fuel Complex, ECIL Post Hyderabad - 500762.

3. Nangal Heavy Water Plant Nangal, Punjab.

4. Baroda Heavy Water Plant
Baroda, Gujarat.

5. Kota Heavy Water Plant
Kota, Rajasthan.

6. Tuticorin Heavy Water Plant
Tuticorin,
Tamil Nadu.

7. Talcher Heavy Water Plant.
Talchar,
Orissa

8. Thal-Vaishet Heavy Water Plant.
Maharashtra.

9. Manuguru Heavy Water Plant.
Vijayawada,
Andhra Pradesh.

10. Power Projects Engineering
Division
Colaba,
Bombay-400005

11. Tarapur Atomic Power Station.
Tarapur,
Bombay

12. Rajasthan Atomic Power Station.
Kota,
Rajasthan

13. Madras Atomic Power Project
Kalpakkam, Tamil Nadu.

14. Narora Atomic Power Project
Narora, U.P.

15. Kakrapur Atomic Power Project
Kakrapur, Gujarat.

INDUSTRIAL UNITS

1. Indian Rare Earths Ltd.
Alwaye, Kerala.

2. Electronics Corporation of
India Ltd.
Cherlapalli,
Hyderabad - 500040.

3. Uranium Corporation of
India Ltd.
Jaduguda Mines
Singhbhum - 832102.

AIDED INSTITUTIONS

1. Tata Institute of
Fundamental Research
Homi Bhabha Road
Colaba, Bombay - 400005.

2. Tata Memorial Centre
De Earnest Borges Marg
Parel, Bombay - 400012.

3. Saha Institute of
Nuclear Physics
Block - AF, Sector 1,
Bidhan Nagar,
Calcutta - 700064.

DEPARTMENT OF ELECTRONICS

DEPARTMENTAL CENTRE

1. National Informatics Centre,
Pushpa Bhawan, 'E' Wing,
Madangir Road,
New Delhi - 110062.

PUBLIC SECTOR UNDERTAKINGS

1. Electronic Trade and Technology
Development Corporation (ETTDC)
15/49 Malcha Marg,
New Delhi - 110021.

2. Computer Maintenance
Corporation (CMC)
8th Floor, Air India Building,
Nariman Point,
Bombay - 400001.

3. Semiconductor Complex Ltd.
Chandigarh

DEPARTMENT OF ENVIRONMENT

1. Zoological Survey of India
34, Chittranjan Avenue,
Calcutta - 700012.

2. Botanical Survey of India
Post Office , Botany Gardens,
Shibpur, Howrah - 700003.

3. National Museum of Natural History
Barakhamba Road,
New Delhi - 110001.

4. Central Board of Preventive and
Control of Water Pollution
6th Floor, Skylark Building,
60 Nehru Place,
New Delhi - 110019.

DEPARTMENT OF SCIENCE & TECHNOLOGY

RESEARCH ORGANIZATIONS/INSTITUTIONS

1. Birbal Sahni Institute
of Palaeobotany
53, University Road,
Lucknow - 226007.

2. Bose Institute
93/1, Acharya Prafulla
Chandra Road
Calcutta - 700009.

3. National Institute of
Immunology
Jawaharlal Nehru University
Campus,
New Delhi - 110029.

4. Raman Research Institute
Hebal P.O.
Bangalore - 560006.

5. Sree Chitra Tirunel Medical
Institute for Science and
Technology,
Trivandrum.

6. Wadia Institute of Himalayan
Geology,
13, Municipal Road,
Dehradun - 248001.

7. National Atlas and Thematic
Mapping Organisation,
50 - A, Garihat Road,
Calcutta - 700019.

SURVEY

8. Survey of India
Block No. 8,
Hathibarkala Estate
Dehradun - 248001.

PARK

9. Padmaja Naidu Himalayan
Zoology Park,
Jawahar Park, Jawahar Parbat,
Darjeeling.

ACADEMY/ASSOCIATION/SOCIETIES

10. Indian National Science
Academy
Bahadur Shah Zafar Marg,
New Delhi - 110002.

11. Indian Science Congress
Association
Dr. Bireshuha Street,
Calcutta - 700017.

12. Indian Association for the
Cultivation of Science,
Jadavpur,
Calcutta - 700032.

13. Maharashtra Association for
the Cultivation of Science,
Law College Road,
Poona - 411004.

14. Bombay Natural History Society
Hornbil House
Shahid Bhagat Singh Road
Bombay - 400023.

15. Indian Academy of Sciences
Bangalore.

PUBLIC SECTOR CORPORATIONS

16. Central Electronics Ltd.,
Industrial Area 4,
Sahibabad - 201005.

17. National Research Development Corporation,
20-22, Jamroodpur Community Centre,
Kailash Colony Extension,
New Delhi - 110048.

DEPARTMENT OF SPACE

1. INSAT-1 Space Segment
Project Office,
Chandra Kiran Building,
Kasturba Road,
Bangalore - 560001.

2. National Remote Sensing Agency,
No. 4. Sardar Patel Road,
Secunderabad - 500003.

3. Physical Research Laboratory,
Navrangapura,
Ahmedabad - 380009.

4. Indian Space Research Organisation,
Headquarters,
Cauvery Bhavan,
Kampegowda Road,
Bangalore - 560009.

5. ISRO Satellite Centre,
A-16, Peenya Industrial Estate,
Bangalore - 560058.

6. Space Applications Centre,
Jodhpur, Tekhra,
Ahmedabad - 380053.

7. SHAR Centre,
Sriharikota, Sullurupeta,
Nellore Dist - 524124.

8. Vikram Sarabhai Space Centre,
Trivandrum - 695002.

9. Auxiliary Propulsion System Unit
Bangalore.

MINISTRY OF AGRICULTURE

DEPARTMENT OF AGRICULTURE AND COOPERATION

ATTACHED OFFICES

1. Agricultural Prices Commission,
Krishi Bhawan,
New Delhi-110001

2. Directorate of Economics and Statistics,
Krishi Bhawan,
New Delhi-110001

3. Directorate of Plant Protection, Quarantine and Storage,
NH-IV, Faridabad,
Haryana.

SUBORDINATE OFFICES

1. Directorate of Extension,
Sector-1, R.K. Puram,
New Delhi-110022

2. Directorate of Sugarcane Development,
No.1, Shyam Enclave,
Giani Border,
Sahibabad, Ghaziabad,
Uttar Pradesh.

3. Directorate of Jute Development,
234/4, Acharya Jagdish Bose Road,
Nizam Palace,
Calcutta-700020.

4. Directorate of Tobacco Development,
27, Eldamas Road, Teynampet,
Madras-600018.

5. Directorate of Oilseeds Development,
Telhan Bhavan,
Himayatnagar,
Hyderabad-500029.

6. Directorate of Rice Development,
241, Patliputra Colony,
Patna-800013.

7. Directorate of Millets Development,
19, Krishnamachari Road,
Madras-600034.

8. Directorate of Cotton Development,
14, Ramjibhai Kamani Marg,
Ballard Estate, P.B.No.1002,
Bombay-400038.

9. Directorate of Pulses Development,
B-2, Sector C, Aliganj Scheme,
Lucknow-226006, U.P.

10. Directorate of Coconut Development,
P.B.No.1027, Ernakulam,
Cochin-682011, Kerala.

11. Directorate of Cocoa, Arecanut and Spices Development,
P.B.No.14,1/500,
Cannanore Road,
Calicut-673006.

12. Directorate of Cashewnut Development,
M.G.Road,
Cochin-682011.

13. Office of Minister (Agriculture),
Embassy of India,
Rome, Italy.

14. Forest Survey of India,
25, Subhash Road,
Old Forest Rangers College,
Dehra Dun.

15. Logging Development Institute,
25, Subhash Road,
Old Forest Rangers Road,
Dehra Dun.

16. Forest Research Institute & Colleges,
P.O. New Forest,
Dehra Dun.

17. Directorate of Lac Development,
Circular Road,
Ranchi, Bihar.

18. Directorate of Agriculture Aviation,
Safdarjung Airport,
New Delhi-110003

19. Central Fertiliser Control Laboratory,
NH-IV, Faridabad, Haryana.

20. Tractor Training & Testing Station,
Tractor Nagar,
Budni, M.P.

21. Tractor Training Centre,
Tractor Nagar,
Hissar, Haryana.

22. Delhi Milk Scheme,
West Patel Nagar,
New Delhi-110008

23. Central Cattle Breeding Farm,
Dhamrod, P.O. Dhamrod,
Distt. Surat, Gujarat.

24. Central Cattle Breeding Farm,
Andeshnagar, Distt. Lakhimpur
U.P.

25. Central Cattle Breeding Farm,
Suratgarh, Rajasthan.

26. Central Cattle Breeding Farm,
Similiguda, P.O. Sunabeda,
Koraput, Orissa.

27. Central Cattle Breeding Farm,
Chiplima, P.O. Kalamati,
Distt. Sambalpur,
Orissa.

28. Central Cattle Breeding Farm,
P.O. Avadhi, Alamadhi,
Madras-600052.

29. Central Cattle Breeding Farm,
Hesserghatta,
Bangalore North.

30. Central Frozen Semen Production
& Training Institute,
Hesserghatta,
Bangalore North.

31. Central Herd Registration Unit,
10, Gautam Vihar Cooperative
Society
Building,
Usmanpura, Ahmedabad-13.

32. Central Herd Registration Unit,
W-15, Jagdish Colony,
Rohtak, Haryana.

33. Central Herd Registration Unit,
34, G.N.M. Colony,
Christianganj,
Ajmer,
Rajasthan-305001.

34. Central Herd Registration Unit,
Santhapet,
Ongole-523001.

35. Regional Station on Forage
Production and Demonstration,
P.O. Netaji Subhash Sanitorium,
Kalyani, Distt. Nadia,
West Bengal.

36. Regional Station on Forage
Production and Demonstration,
48, Rajbagh(Extension),
Srinagar,
J&K.

37. Regional Station on Forage
Production and Demonstration,
Suratgarh, Rajasthan.

38. Regional Station on Forage
Production and Demonstration,
P.O. Textile Mill,
Hissar, Haryana.

39. Regional Station on Forage
Production and Demonstration,
GA 128/2, Sector No.30,
Gandhi Nagar,
Gujarat.

40. Regional Station on Forage
Production and Demonstration,
Avadhi, Alamadhi,
Madras-600052.

41. Regional Station on Forage
Production and Demonstration,
Mamidipalli, Via Deshavagiri,
Hyderabad-500005.

42. Animal Quarantine and
Certification Service Station,
Delhi Gurgaon Road,
Kapashera Village,
New Delhi.

43. Animal Quarantine &
Certification Service Station,
No.1, Naickers Colony,
Pallavaram,
Madras-600043.

44. Animal Quarantine &
Certification Service Station,
10, H.L. Sarkar Road,
Bansdroni,
Distt.24, Parganas,
West Bengal.

45. Animal Quarantine & Certification Service Station, C/o Central Poultry Breeding Farm, Aarey Milk Colony, Bombay-400065.

46. Central Sheep Breeding Farm, 158-N, Model Town, Hissar, Haryana.

47. Central Poultry Breeding Farm, Aarey Milk Colony, Bombay-400065.

48. Central Poultry Breeding Farm, Bhubaneswar-751012 Orissa.

49. Central Poultry Breeding Farm, Hesserghatta, Bangalore North.

50. Central Poultry Breeding Farm, Industrial Area, Chandigarh.

51. Central Duck Breeding Farm, Hesserghatta, Bangalore North.

52. Central Institute of Poultry Production and Management, Hesserghatta, Bangalore North.

53. Random Sample Laying Test Unit, Hesserghatta, Bangalore North.

54. Random Sample Laying Test Unit, Bhubaneswar-751012, Orissa.

55. Random Sample Laying Test Unit, C/o Aarey Milk Colony, Bombay-400065.

56. Random Sample Laying Test Unit, 49/4, Urban Estate, Gurgaon, Haryana.

57. Large Fodder Seed Production Farm, Hesserghatta, Bangalore North.

58. Exploratory Fisheries Project, Botwala Chambers, Sir P. Mehta Road, Bombay-400001.

59. Central Institute of Nautical Engineering and Training, Dewans Road, Ernakulam, Cochin-682016.

60. Pre-investment Survey of Fishing Harbours Project, 64, Palace Road, Bangalore-560042.

61. Integrated Fisheries Project, P.B.No.1801, Cochin-682016.

62. All India Soil and Land Use Survey Organization, I.A.R.I. Building, New Delhi-110012.

63. Soil Conservation Research Demonstration and Training Centre, Chatra, P.O.Jogbani, Distt. Purnea, Bihar.

PUBLIC SECTOR UNDERTAKINGS

1. State Farms Corporation of India, Beej Bhavan, Pusa Institute Complex, C.T.O. Building, New Delhi -110012.

2. National Seeds Corporation, Beej Bhavan, Pusa Institute Complex, C.T.O. Building, New Delhi-110012.

3. Andaman and Nicobar Forest Plantation Development Corporation, Port Blair.

4. Indian Dairy Corporation, 'Yashkamal', 7th Floor, P.O.Sayaigunj, Baroda - 390005.

5. Central Fisheries Corporation,
62, Rose Mary Lane, P.B. No: 86
GPO, Howrah, Calcutta.

AUTONOMOUS ORGANISATIONS

1. National Cooperative
Development Corporation,
4, Siri Institutional Area,
Hauz Khas,
New Delhi-110016.

2. Animal Welfare Board,
First Main Road, Gandhi Nagar,
Madras-600020.

3. National Dairy Development
Board,
Anand, Gujarat.

4. Coconut Development Board,
Mahatma Gandhi Road,
Ernakulam,
Cochin-682011.

5. Indian Institute of Forest
Management,
E-5/120, Arere Colony,
Bhopal, M.P.

NATIONAL LEVEL COOPERATIVE FEDERATION

1. National Cooperation Union
of India,
No. 3, Siri Institutional Area,
Panch Sheel Marg,
New Delhi-110016.

2. National Agricultural
Cooperative Marketing
Federation of India Ltd.,
Saona Building,
54, East of Kailash,
New Delhi-110024.

3. National Cooperative Consumers
Federation Ltd.,
Deepali (5th Floor),
92, Nehru Place,
New Delhi-110024.

4. Indian Farmers Fertiliser
Cooperative Ltd.
34, Nehru Place,
New Delhi-110024.

5. National Federation Cooperative
Sugar Factories Ltd,.
Vaikunth (3rd Floor),
82-83 Nehru Place,
New Delhi-110024.

6. The National Federation
of Industrial Cooperative Ltd.,
204, (2nd Floor),
Prabhat Kiran Bld.,
Rajindra Place, Pusa Road,
New Delhi-110008.

7. Petrofils Cooperative Ltd.,
New Delhi House,
27, Barakhamba Road,
New Delhi-110001.

8. National Heavy Engineering
Cooperative Ltd.,
16, Mahatma Gandhi Road,
Pune-411001.

9. The National Cooperative
Housing Federation Ltd.,
34, South Patel Nagar,
New Delhi-110008.

10. National Cooperative Dairy
Federation of India,
IDA House, Sector IV,
R.K. Puram,
New Delhi-110022.

11. National Federation of Urban
Cooperation Banks and Credit
Societies,
3, Netaji Subhash Marg,
Daryaganj,
New Delhi-110002.

12. The All India Federation
of Cooperative Spinning
Mills Ltd.,
14, Murzban Road, 2nd Floor,
Bombay-400001.

13. National Cooperative Land Development Banks Federation, Shivasakti, 2nd Floor, B.C. Kher Road, Worli, Bombay - 400018.

14. National Federation of State Cooperative Banks, P.B.No. 9921, Garment House, Dr. Annie Besant Road, Worli, Bombay-400018.

15. The All-India Industrial Cooperative, Banks Federation, 11, Bull Temple Road, Basavanagudi, Bangalore-560004.

16. The All-India Handloom Fabrics Marketing Cooperative Society Ltd., G.P.O. Box No. 1121(5th Floor), 56-58, Mittal chambers, Nariman Point, Bombay-400021.

17. All-India Fishermen Cooperative Federation Ltd., 3, Siri Industrial Area, Pench Sheel Marg, New Delhi-110016.

18. Krishak Bharti Cooperative Ltd., 34, Nehru Place, New Delhi-110024.

19. National Federation of Labour Cooperation Ltd., 4, Jantar Mantar Lane, New Delhi-110001.

DEPARTMENT OF AGRICULTURAL RESEARCH & EDUCATION

1. National Academy of Agricultural Research Management. Hyderabad-500030.

2. Agricultural Scientists Recruitment Board, 26, Barakhamba Road, New Delhi-110001.

MINISTRY OF COMMERCE

DEPARTMENT OF COMMERCE

RESEARCH AND TRAINING INSTITUTE

1. Central Sericulture Station, Behrampur-142101.

2. Central Sericultural Research and Training Institute, 78, Devi Niwas, Nazarbad , Mysore -857010.

3. Central Tasar Research Station, Hebal, Ranchi-834005.

4. Central Muga & Eri Research Station, Titabar-785632.

5. Central Coffee Research Institute, Chickmagalore, Karnataka.

6. Rubber Research Institute of India, Rubber Board, Kottayam-9.

7. UPASI Tea Research Station, P.O. Cinchona-642106.

AUTONOMOUS BODIES

1. Indian Institute of Forgein Trade,
Ashok Bhawan,
93, Nehru Place,
New Delhi-110019

2. Indian Institute of Packaging,
Bombay.

3. Federation of Indian Export Organisations,
PHD House, 3rd Floor,
4/2 Siri Institutional Area,
Hauz Khas,
New Delhi-110016

4. Indian Council of Arbitration,
Federation House
New Delhi-110001

5. Trade Development Authority,
Bank of Baroda Building
16, Parliament Street
New Delhi-110001

6. Marine Products Export Development Authority,
Cochin, Kerela.

7. The Trade Fair Authority of India,
Administrative Building
Pragati Maidan
New Delhi-110001

PUBLIC SECTOR UNDERTAKINGS

1. The State Trading Corporation of India,
Chandralok, 36, Janpath,
New Delhi-110001.

2. The Cashew Corporation of India Ltd.,
P.B. 1216, M. Gandhi Road,
Cochin-682011.

3. The Projects & Equipment Corporation Ltd.,
Hansalaya, 15, Barakhamba Road,
New Delhi-110001.

4. The Handicrafts and Handloom Export Corporation Ltd.,
Lok Kalyan Bhavan, 11 A,
Rouse Ave. Lane,
New Delhi-110001.

5. The Minerals and Metals Corporation of India Ltd.,
Express Building,
9 & 10 B Shah Zafar Marg,
New Delhi-110001.

6. Mica Trading Corporation,
137, Pattiputra Colony,
Patna-800013.

7. The Export Credit and Gurantee Corporation Ltd.,
Express Towers,
10th Floor,
Nariman Point,
Bombay-400021.

8. The Trading Corporation of India,
225 F Acharya J.C. Bose Road,
Calcutta-700020.

DEPARTMENT OF TEXTILES

PUBLIC SECTOR UNDERTAKINGS

1. National Textile Corporation Ltd.,
8th Floor, Surya Kiran Bldg.,
Kashturba Gandhi Marg,
New Delhi-110001.

2. Cotton Corporation of India Ltd.,
Air India Bldg., 12th Floor,
Nariman Point,
Bombay -400021.

3. Jute Corporaation of India Ltd.,
1, Shakespeare Sarani,
Calcutta-700071

4. National Jute Manufactures Corporation,
Calcutta.

5. Handicrafts and Handlooms Export Corporation,
Lok Kalyan Bhavan,
11 A Rouse Ave Lane,
New Delhi-110001.

6. Central Cottage Industries Corporation of India Ltd.,
Janpath,
New Delhi-110001.

7. North-Eastern Handicrafts and Handlooms Development Corporation,
Bomfyle Road,
Shillong-793001.

8. British India Corporation,
Kanpur.

9. National Handloom Development Corporation.
Lucknow

TEXTILE RESEARCH ASSOCIATIONS

1. Ahmedabad Textile Industry's Research Association,
Polytechnic P.O.,
Ahmedabad-380015

2. Bombay Textile Research Association,
Lal Bhadur Shastri Marg,
G Lat Kopar (West),
Bombay-400086

3. South India Textile Research Association,
Aerodrome P.O.,
Coimbatore-641014

4. Northern India Textile Research Association,
Ghaziabad.

5. Silk and Artsilk Mills' Research Association,
SASMIRA Marg, Worli,
Bombay-400025

6. Man-made Textile Research Association,
Surat.

7. Indian Jute Industry's Research Association,
17, Taratola Road,
Calcutta-700053

8. Wool Research Association,
C/O SASMIRA,
Dr. Annie Besant Road,
Worli,
Bombay-400025

EXPORT PROMOTION COUNCILS

1. Handloom Export Promotion Council,
Madras.

2. Apparels Export Promotion Council,
4th Floor, Sahyog Building,
58, Nehru Place,
New Delhi-110019

3. Cotton Textiles Export Promotion Council,
Bombay.

4. The Silk and Rayon Textiles Export Promotion Council,
Bombay.

5. Wool and Woollens Export Promotion Council,
Bombay.

MINISTRY OF COMMUNICATION

MAIN MINISTRY

1. Overseas Communication Service,
   Videsh Sanchar Bhavan,
   NIG Road, Fort,
   Bombay-400001.

PUBLIC SECTOR UNITS

1. The Hindustan Teleprinters
   Ltd.,
   Guindy,
   Madras-600032.

2. Indian Telephone
   Industries Ltd.,
   16, Museum Road,
   Bangalore-560001.

INDIAN POSTS & TELEGRAPHS DEPARTMENT

PUBLIC SECTOR UNIT

1. Telecommunication Consultants
   India Ltd.,
   Chiranjiv Tower, 3rd Floor,
   43, Nehru Place,
   New Delhi-110019.

R&D UNIT

1. Telecommunication
   Research Centre,
   Khurshid Lal Bhavan,
   Janpath,
   New Delhi-110001.

MINISTRY OF DEFENCE

DEPARTMENT OF DEFENCE PRODUCTION

1. Hindustan Aeronautics Ltd.,
   Post Bag No. 1789,
   Bangalore-560017.

2. Bharat Electronics Ltd.,
   29, Race Course Road,
   Bangalore-560001.

3. Bharat Earth Movers Ltd.,
   J.C. Road,
   Bangalore-560002.

4. Mazagon Dock Ltd.,
   Dock Yard Road,
   Mazagaon,
   Bombay-400010.

5. Garden Reach Shipbuilders
   and Engineers Ltd.,
   43/46, Garden Reach,
   Calcutta-700024.

6. Goa Shipyard Ltd.,
   Vasco-de-Gama,
   Goa.

7. Praga Tools Ltd.,
   6-68/32, Vivaduguda Road,
   Secunderbad-500003.

8. Bharat Dynamics Ltd.,
   10-3-310, Masab Tank,
   Hyderabad-500028.

9. Misra Dhatu Nigam Ltd.,
   Kanchan Bagh,
   Hyderabad-500258.

DEPARTMENT OF DEFENCE RESEARCH & DEVELOPMENT

1. Defence Research and
Development Orgnisation,
South Block,
New Delhi-110011

DEPARTMENT OF DEFENCE

1. Institute of Aviation Medicine
Indian Air Force,
P.O. Vimanpure,
Bangalore-560017.

MINISTRY OF EDUCATION & CULTURE

DEPARTMENT OF EDUCATION

ORGANISATIONS/INSTITUTIONS

1. National Archives of India,
Janpath,
New Delhi-110001.

2. National Council of Educational
Research and Training,
NIE Campus,
Sri Aurobindo Marg,
New Delhi-110016.

3. National Institute of
Educational Planning
and Administration,
17B, Sri Aurobindo Marg,
New Delhi-110016.

4. Indian Institute of Advnanced
Study,
Simla, H.P.

13. Indian Institute of Technology,
(5 Nos.)

14 Indian Institute of Science,
Bangalore.

15. Regional Engineering Colleges,
(15 Nos.)

16. Indin Institute of Management,
(3 Nos.)

17. Technical Teachers' Training
Institutes (4 Nos).

18. Indian School of Mines,
Dhanbad, Bihar.

19. School of Planning and
Architecture,
I.P Estate,
New Delhi-110002.

20. National Institute of Training
in Industrial Engineering,
Bombay.

21. National Institute of Foundary
and Forge Technology,
Ranchi.

22. Indian Council of Social
Science Research,
IIPA Hostel Building,
I.P. Estate,
New Delhi-110001.

23. Indian Council of Historical
Research,
35, Faroz Shah Road,
New Delhi-110001.

DEPARTMENT OF CULTURE

1. Archaeological Survey of India
   Janpath,
   New Delhi-110001

2. National Council of Science
   Museums,
   196, Gurusaday Road,
   Calcutta-700019.

3. Birla Industrial &
   Technological Museum,
   Calcutta,

4. Visvesvaraya Industrial &
   Technological Museum,
   Bangalore,

5. Nehru Science Centre,
   Bombay.

MINISTRY OF ENERGY

DEPARTMENT OF PETROLEUM

PUBLIC SECTOR UNDERTAKINGS

1. Oil & Natural Gas Commission,
   Kaulagarh Road,
   Dehradun-248005.

2. Indian Oil Corporation Ltd.,
   Oil Bhavan,
   Janpath,
   New Delhi-110001.

3. Bharat Petroleum
   Corporation Limited,
   ECE House, Canaught Circus,
   New Delhi-110001.

4. Hindustan Petroleum
   Corporation Limited,
   J. Tata Road,
   Bombay-400020.

5. Cochin Refineries Limited,
   P. Bag 1751,
   Cochin.

6. Madras Refineries Limited,
   Madras-600068

7. Indo-Burma Petroleum
   Company Limited,
   11, Floor, Hindustan
   Times House,
   K. Gandhi Marg,
   New Delhi-110001.

8. Engineers India Limited,
   PTI Building,
   4, Parliament Street,
   New Delhi-110001.

9. Lubrizol India Limited,
   Delater 9 A.S. Patkar Marg,
   Bombay-400036.

10. Indian Patrochemicals
    Corporation Limited,
    P.O. Petrochemicals,
    Vadodara.

11 Bongaigaon Refinery and
   Petrochemicals Limited,
   P.O. Dhaligaon,
   Via New Bongaigaon Rly.Station,
   Assam-783385.

12. Biecco Lawrie Limited
    21, Netaji Subhas Road,
    Calcutta-700001

13. Bridge and Roof Co.
    (India) Limited.
    21, Netaji Subhas Road,
    Calcutta-70001.

14. Petrofils Cooperative Limited,
    New Delhi House,
    Barakhamba Road,
    New Delhi-110001.

SUBSIDIARIES

1. Hydrocarbons India Limited,
   Bank of Baroda Building,
   7, Floor Sansad Marg,
   New Delhi-110001.

2. Indian Oil Blending Limited,
   Pharpur ,
   Calcutta-700043

3. Balmer Lawrie &
   Company Limited,
   P-4/1, Oil Installation Road,
   Calcutta-700043.

JOINT SECTOR COMPANY

1. Oil India Limited,
   17, Sansad Marg,
   New Delhi-110001.

OTHER ORGANISATIONS

1. Oil Coordination Committee,
   Kailash Building,
   26, K. Gandhi Marg,
   New Delhi-110001.

2. Petroleum Conservation Research
   Association,
   709, Surya Kiran Building,
   19, K Gandhi Marg,
   New Delhi-110001.

3. Central Institute of Plastic
   Engineering & Tools,
   Madras .

DEPARTMENT OF POWER

Central Electricity Authority,
Seva Bhawan, North Wing,
R.K. Puram,
New Delhi-110022.

PUBLIC SECTOR UNDERTAKINGS

1. National Thermal Power
   Corporation,
   62, Skipper House,
   Nehru Place,
   New Delhi-110019.

2. National Hydroelectric Power
   Corporation Ltd.,
   Manjusha Building,
   57, Nehru Place,
   New Delhi-110019.

3. National Projects Construction
   Corporation Ltd.,
   Raja House,
   13, Nehru Place,
   New Delhi-110019.

4. Rural Electrification
   Corporation Ltd.,
   D.D.A. Building,
   Nehru Place,
   New Delhi-110019.

5. Damodar Valley Corporation,
   Calcutta

6. Bhakra Beas Management Board,
   Chandigarh

OTHER ORGANISATIONS

1. Central Power Research
   Institute,
   Bangalore.

2. Power Engineers Training
   Society,
   Faridabad

3. Central Board of
   Irrigation and Power.
   Malcha Marg,
   Chanakayapuri,
   New Delhi-110021

DEPARTMENT OF COAL

SUBSIDIARY BODIES

1. Nayveli Lignite Corporation,
   Nayveli-607801,
   Tamilnadu.

2. Coal India Limited,
   10, Netaji Subhas Road,
   Calcutta-700001.

PUBLIC SECTOR UNDERTAKING

1. Central Coalfields Ltd.,
   Sangtoria, P.O.
   Dishergarh-718333.

2. Western Coalfields Ltd.,
   Bisesar House,
   Temple Road,
   Nagpur-440001.

3. Eastern Coalfield Ltd.,
   Sanctorio, P.O.
   Dishergarh-718333.

4. Bharat Coking Coal Ltd.,
   Bhuggatdin Building,
   Jharia-828111,
   Dhanbad.

5. Central Mine Planning
   Design Institute,
   Gondwana Place,
   Kanke Road,
   Ranchi-834008.

   Singareni Collieries
   Company Ltd.,
   Kothagudem, A.P.

DEPARTMENT OF NON-CONVENTIONAL SOURCES OF ENERGY

1. Commission for Additional
   Sources of Energy,
   New Delhi-110001.

MINISTRY OF FOOD & CIVIL SUPPLIES

DEPARTMENT OF FOOD

PUBLIC SECTOR UNDERTAKINGS

1. Food Corporation of India,
   16-20 Barakhamba Road,
   New Delhi-110001.

2. Central Warehousiong
   Corporation,
   4/1 Siri Industrial Area,
   Houz Khas,
   New Delhi-110016.

3. North-Eastern Agricultural
   Marketing Corporation Ltd.

4. Modern Bakeries Ltd.,
   Basant Vihar,
   New Delhi-110057

RESEARCH AND TRAINING INSTITUTIONS

1. Indian Grain Storage Institute,
   Hapur, U.P.

2. National Sugar Institute,
   Kanpur-208017.

3. Institute of Hotel Management,
   Catering Technology and Applied
   Nutrition (4 Nos.)

4. Modern Bakeries Ltd.,
   Vasant Vihar,
   New Delhi-110057.

DEPARTMENT OF CIVIL SUPPLIES

1. Indian Standard Institution,
Manak Bhawan,
9, Bahadur Shah Zafar Marg,
New Delhi-110001.

MINISTRY OF HEALTH & FAMILY WELFARE

DEPARTMENT OF HEALTH

PREVENTION OF FOOD AND ADULTERATION RESEARCH LABORATORIES

1. Central Food Laboratory
3, Kyd Street,
Calcutta - 700016.

2. Central Indian Pharmacopoeia
Laboratory,
Ghaziabad.

MEDICAL EDUCATION, TRAINING, RESEARCH AND REGULARITY BODIES

1. Medical Council of India
Medical Council Building,
Diwan-E-Galib Marg,
Kotla Road,
New Delhi - 110012.

2 National Academy of
Medical Sciences
C 11/16 Ansari Nagar,
New Delhi - 110029.

3. Dental Council of India
Temple La Kotla Road,
New Delhi - 110002.

4. India Nursing Council
Combined Council Building,
Temple La Kotla Road,
New Delhi - 110002.

5. Pharmacy Council of India
Temple La Kotla,
New Delhi - 110012.

PREMIER INSTITUTIONS

6. All India Institute of
Medical Sciences,
Ansari Nagar,
New Delhi - 110016.

7. Post-Graduate Institute
of Medical Education
& Research,
Sector - 12,
Chandigarh - 160001.

8. Jawaharlal Nehru Institute
of Post-Graduate Medical
Education and Research,
Pondichery - 605006.

9. V.P. Chest Institute
Post Bag No. 2101
New Delhi - 110007.

RESEARCH INSTITUTES

10. National Institute of
Communicable Diseases,
22, Shamnath Marg,
New Delhi - 110006.

11. Central Research Institute
P.O. Kasauli, H.P.

12. National T.B. Institute
8, Bellary Road
Bangalore - 560003.

13. Central Leprosy Teaching
and Research Institute
Post Box 1,
Chingleput - 603001.

14. National Institute of Mental and Neuro Sciences
P.O. Lal Bagh, Shantinagar,
Bangalore - 560027.

15 All India Institute of Physical Medicine and Rehabilitation
Clark Road, Mahalaxmi,
Bombay - 400034.

16. All India Institute of Speech Hearing
Maharaja College,
Centenary Hall,
Mysore - 570005.

17. All India Institute of Hygiene and Public Health,
110, Chittaranjan Avenue
Calcutta - 700073.

18. Pasteur Institute of India
Conoor - 643103.

19. Central Institute of Psychiatry
Ranchi,Bihar.

20. Central Health Education Bureau,
Nirman Bhawan,
New Delhi.-110011

21. Central Bureau of Health Intelligence,
New Delhi

22. Indian Council of Medical Research,
Medical Enclave,
Ansari Nagar,
New Delhi-110029

INDIAN SYSTEM OF MEDICINE AND HOMEOPATHY

1. Central Council for Research in Ayurveda and Siddha
Dharma Bhawan,
S-10 Green Park
Extention Market
New Delhi-110016

2. The Institute of History of Medicine and Medical Research,
Tuglakabad, P.O. Madangir,
New Delhi-110062

3. National Institute of Ayurveda
Jaipur

4. Central Council for Research in Unani Medicine
5 Panch Sheel Shopping Centre
New Delhi-110017

5. Central Council for Research in Homeopathy,
10 Community Centre,
Basant Lok,
Basant Vihar,
New Delhi-110057

6. National Institute of Homeopathy
Calcutta.

7. Homeopathic Pharmacopoeia Laboratory,
Ghaziabad.

8. Central Council for Research in Yoga and Neuropathy,
New Delhi-110001

9. Central Research Institute for Yoga
New Delhi-110001

DEPARTMENT OF FAMILY WELFARE

AUTONOMOUS AND SUBORDINATE ORGANISATIONS

1. National Institute of Health and Family Welfare
   Near DDA Flats, Munirka,
   New Delhi - 110067.

2. International Institute of Population Studies,
   Deonar, Bombay - 400088.

3. Hindustan Latex Ltd.,
   Trivandrum.

4. Family Welfare, Training and Research Centre
   381, Sardar Vallabhai Patel Road
   Bombay - 400004

MINISTRY OF HOME AFFAIRS

1. Bureau of Police Research and Development,
   8-168, Curzon Road Barracks,
   New Delhi-110001.

2. Central Forensic Science Laboratory,
   Central Bureau of Investigation,
   East Block VII, R.K. Puram,
   New Delhi-110022.

3. Central Forensic Science Laboratory,
   30, Gorachan Road,
   Calcutta-700014.

4. Central Forensic Science Laboratory,
   5-9-201/2, Chirag Ali Lane,
   Hyderabad.

5. Institute of Criminology and Forensic Science,
   A-2/19, Safdarjung Enclave,
   New Delhi-110029.

MINISTRY OF INFORMATION & BROADCASTING

1. Research Development,
   All India Radio,
   I.P. Estate, Ring Road,
   New Delhi-110002.

2. Indian Institute of Mass Communication,
   D-13, N.D.S.E. Part-II,
   New Delhi-110049.

MINISTRY OF INDUSTRY

DEPARTMENT OF INDUSTRIAL DEVELOPMENT

ATTACHED OFFICES

1. Directorate General of Technical Development,
Udyog Bhavan,
New Delhi-110011.

2. Organisation of Development Commissioner for Small Scale Industries,
Nirman Bhavan,
New Delhi-110011.

3. Bureau of Industrial Costs & Prices,
7th Floor, Lok Nayak Bhavan,
New Delhi-110003.

4. Directorate General of Industrial Contingency,
New Delhi.

5. Office of the Cement Controller,
7, Rajindra Place,
New Delhi-110008.

SUBORDINATE OFFICES

1. Office of the Chief Controller of Explosives,
Nagpur.

2. Patent Office,
Nagpur.

3. Integrated Training Centre,
Nilokheri,Harayana

PUBLIC SECTOR UNDERTAKINGS

1. National Industrial Development Corporation Ltd.,
Chankaya Bhavan,
Vinay Marg,
New Delhi-110021.

2. National Small Industries Corporation Ltd.,
New Okhla Industrial Estate,
New Delhi-110020.

3. Cement Corporation of India Ltd.,
59, Nehru Place,
New Delhi-110019.

4. Hindustan Photo films Manufacturing Co.Ltd.,
Indu Nagar,
Ootacamund-643005.

5. Bharat Ophthalmic Glass Ltd.,
Durgapur-10,W.B. .

6. National Instruments Ltd.,
1/1, Raja Subodh Chandra Mullick Road,
Calcutta-700032.

7. Instrumentation Ltd.,
Kota-324995.

8. Hindustan Cables Ltd.,
Rupnarainpur,
Burdwan Distt.,W.B.

9. National Newsprint & Paper Mills Ltd.,
Nepanagar-450221.,M.P.

10. Hindustan Paper Corporation Ltd.,
C-75, Park Street,
Calcutta-700016.

11. Hindustan Salts Ltd.
Parijat Bhavan,
Ashok Marg,
Jaipur-392998.

12. Sambhar Salts Ltd.,
Parijat Bhavan,
Ashok Marg,
Jaipur-392998.

13. Tannery and Footwear Corporation Ltd., Civil Lines, Kanpur., U.P.

14. Bharat Leather Corporation Ltd., Noida.

15. Andrew Yule & Co.Ltd., Calcutta.

16. National Bicycle Corporation of India Ltd., Bombay.

17. Cycle Corporation of India Ltd., Calcutta.

OTHER OFFICES/BODIES

1. Coir Board, Cochin.

2. Central Boilers Board, New Delhi.

3. National Productivity Council, Institutional Area, Lodhi Road, New Delhi-110003.

4. Small Industries Extension Training Institute, Hyderabad.

5. Central Institute of Tool Design, Hyderabad.

6. Institute for Design of Electrical Measuring Instruments, Bombay.

7. Central Tool Room and Training Centre, Calcutta.

8. Tool Room & Training Centre, Ludhiana.

9. Hand Tool Institute, Jullundhur.

10. Tool Room & Training Centre, New Delhi.

11. National Institute of Design, Paldi, Ahmedabad.

12. National Federation of Industrial Cooperatives, New Delhi.

13. Cement Research Institute of India, Ballabhgarh(Haryana).

14. Indian Plywood Industries Research Institute, P.O.No.2273, Tumkur Road, Bangalore-560022.

15. Khadi & Village Industries Commission, 3, Irla Road, Ville Parle(W), Bombay-400056.

16. Central Pulp & Paper Research Institute, Dehradun,U.P.

17. Indian Rubber Manufactures Research Association, Plot No.88, Road 4, Wagle Industries Estate, Thana,Maharashtra

DEPARTMENT OF HEAVY INDUSTRY

RESEARCH INSTITUTIONS

1. Automative Research Association of India,
   Post Box No.825,
   Pune-411104.

2. Central Metal Forming Institute,
   Hyderabad.

3. Central Machine Tool Institute,
   Tumkur Road,
   Bangalore-569923.

PUBLIC SECTOR UNDERTAKINGS

1. Bharat Heavy Electricals Ltd.,
   Hindustan Times House,
   18-20, Kasturba Gandhi Marg,
   New Delhi-110001.

2. Bharat Heavy Plates and Vessels Ltd.,
   P.O.Box No.100,
   Vishakhapatnam-530012.

3. Bharat Pumps & Compressor Ltd.,
   Naini,
   Allahabad-211919.

4. Bharat Wagon Engineering Co.Ltd.
   66, Patliputra Colony,
   Patna-800013.

5. Braithwaite & Co.Ltd.
   5, Hide Road,
   Calcutta-700043.

6. Burn Standard Co.Ltd.,
   10-C, Hungerford Street,
   Calcutta-700017.

7. Heavy Engineering Corporation Ltd.,
   Ranchi-834004.

8. Hindustan Machine Tools Ltd.,
   36, Cunningam Road,
   Bangalore-560052.

9. Jessep & Co.Ltd.,
   63, Netaji Subhash Road,
   Calcutta-700001.

10. Lagan Jute Machinery Co.Ltd.
    Calcutta

11. Mining & Allied Machinery Corporation Ltd.,
    P.O.Durgapur-10.

12. Richardson & Cruddas Ltd.,
    Byculla Iron Works,
    Post Bag No.4503,
    Bombay-400008.

13. Scooters India Ltd.,
    P.O. Sarojini Nagar,
    Lucknow-226008.

14. Triveni Structurals Ltd.,
    Naini,
    Allahabad-211919.

15. Tungabhadra Steel Products Ltd.,
    P.O.Tunghbadra Dam-583225.

16. Engineering Project(India) Ltd.
    Kailash Building,
    K. Gandhi Marg,
    New Delhi-110001.

17. Maruti Udyog Ltd.,
    Palam Gurgaon Road,
    Gurgaon,Haryana.

MINISTRY OF IRRIGATION

ATTACHED OFFICES

1. Central Water Commissioner,
   Seva Bhavan,
   R.K. Puram,
   New Delhi-110022.

2. Central Soil & Materials
   Research Station,
   Near IIT Hostel,
   Outer Ring Road,
   Hauz Khas,
   New Delhi-110016.

SUBORDINATE ORGANISATIONS

1. Central Water & Power
   Research Station,
   Khadakwasla,
   Pune-411024.

2. Central Ground Water Board,
   Jamnagar House,
   Mansingh Road,
   New Delhi-110001.

3. Ganga Flood Control Commission,
   Patna.

4. Sone River Commission,
   Patna.

5. Bansagar Control Board,
   Rewa.

6. Mahi Control Board,
   Udaipur.

MINISTRY OF PETROLEUM, CHEMICALS & FERTILIZERS

DEPARTMENT OF CHEMICALS & FERTILIZERS

PUBLIC SECTOR UNDERTAKINGS

1. Fertilizer Corporation
   of India Ltd.,
   Madhuban, 55, Nehru Place,
   New Delhi-110019.

2. Fertilizers & Chemicals
   Travancore Ltd.,
   Udyogmandal
   Alwaye-683501.
   Kerala.

3. National Fertilizers Ltd.,
   20, Community Centre,
   East of Kailash,
   New Delhi-110065.

4. Rashtrya Chemicals and
   Fertilizers Ltd.,
   Marvali,Chembur,
   Bombay-400074.

5. Madras Fertilizers Ltd.,
   Manali,
   Madras-600068.

6. Pyrites, Phosphates and
   Chemicals Ltd.,
   6, Community Centre,
   East of Kailash,
   New Delhi-110065.

7. Fertilizers(P&D) India Ltd.,
   CIFT Building,
   P.O. Sindri-828122,
   Bihar.

8. Hindustan Fertilizer
   Corporation Ltd.,
   Nehru Place,
   New Delhi-110019.

9. Paradeep Phosphates Ltd.

10. Hindustan Organic Chemicals Ltd.,
P.O. Rasayani-410207,
Maharashtra.

11. Hindustan Insecticides Ltd.,
Hans Bhavan,
Bhadur Shah Zafar Marg,
New Delhi-110002.

12. Indian Drugs &
Pharmaceuticals Ltd.,
Dundahera Industrial Complex,
Dhundahera, Gurgaon Road,
Gurgaon-122001.

13. Hindustan Antibiotics Ltd.,
Pimpri,
Pune-411018.

14. Smith Stanistreet
Pharmaceuticals Ltd.,
Calcutta-700014.

15. Bengal Chemicals and
Pharmaceuticals Ltd.,
6, Ganesh Chander Avenue,
Calcutta-700013.

16. Bengal Immunity Co.Ltd.,
153, Dharamtolla Street,
Calcutta-700013.

MINISTRY OF PLANNING

DEPARTMENT OF STATISTICS

1. Central Statistical Organisation,
Sardar Patel Bhavan,
Sansad Marg,
New Delhi-110001.

2. Computer Centre,
East Block 10,
R.K. Puram,
New Delhi-110022.

3. National Sample Survey
Organisation,
Sardar Patel Bhavan,
Sansad Marg,
New Delhi-110001.

4. Indian Statistical Institute,
203 B.T. Road,
Calcutta-700035.

MINISTRY OF RAILWAYS

RAILWAY BOARD

PUBLIC SECTOR UNDERTAKINGS

1. The Rail India
Technical & Economic
Services Ltd.,
Ist Floor, New Delhi House,
27, Barakhamba Road,
New Delhi-110001.

2. The Indian Railways
Construction Co.Ltd.,
Rattan Jyoti Building,
2nd Floor, 18,Rajindra Place,
New Delhi-110008.

R&D UNIT

1. Research,Design & Standards
Organisation,
Manak Nagar,
Lucknow-226011.

BOARD

1. Central Board of Railway Research, Rail Bhawan, New Delhi-110001.

IV PRODUCTION UNITS

1. Chittaranjan Locomotive Works, Chittaranjan-71331, West Bengal.
2. Diesel Locomotive Works, Varanasi-221001, Uttar Pradesh.
3. Integral Coach Factory, Perambur, Madras-600038.

MINISTRY OF RURAL DEVELOPMENT

INSTITUTIONS/SOCIETIES

1. Directorate of Marketing and Inspection, Faridabad.
2. National Institute of Rural Development, Hyderabad.
3. People's Action for Development(India), A-1, Nizamuddin West, New Delhi-110013.
4. Council for Advancement of Rural Technology, New Delhi.

MINISTRY OF SHIPPING & TRANSPORT

PUBLIC SECTOR UNDERTAKING

1. Shipping Corporation of India, Shipping House, 245, M. Cama Road, Bombay-400021.
2. Mogel Line Ltd., 16, Bank Street, Bombay-400023.
3. Hindustan Shipyard Ltd., Visakhapatnam-53005, Andhra Pradesh.
4. Cochin Shipyard Ltd., P.B 1653, Cochin-682015.
5. Central Inland Water Transport Corpn.Ltd., 4 Fairlie Place, Calcutta-700001.
6. Indian Road Construction Corporation, Raja House, Nehru Place, New Delhi-110019.

MINISTRY OF STEEL & MINES

DEPARTMENT OF STEEL

PUBLIC SECTOR UNDERTAKINGS

1. Steel Authority of India Ltd.
Ispat Bhawan,
Lodi Bhawan
New Delhi-110003.

2 Indian Iron & Steel Co. Ltd.,
ISCO House, 50 Chowringhee Road,
Calcutta-700071.

3. Metal Scrap Trade Corporation Ltd.,
225,F, Acharya Jagadish Bose Road,
Calcutta-700020.

4. Visvesvaraya Iron & Steel Ltd.,
Bhadravati-577301
Karnataka.

5. R&D Centre for Iron & Steel,
Hindustan Steel Ltd.,
Ranchi-834002.

6. National Mineral Development Corporation Ltd.,
109, Surya Kiran Building,
Kasturba Gandhi Marg,
New Delhi-110001.

7. Manganese Ore(India) Ltd.,
3, Mount Road Ext.,
P.O. 34,
Nagpur-440001.

8. Metallurgical & Engineering Consultants (India) Ltd.,
P.O. Hinoo,
Ranchi-834002,
Bihar.

9. Hindustan Steelworks Construction Ltd.,
1, Shakespeare Sarani,
(8th Floor),
Calcutta-700071.

DEPARTMENT OF MINES

SURVEY AND BUREAU

1. Geological Survey of India,
27, Jawaharlal Nehru Road,
Calcutta-700013.

2. Indian Bureau of Mines,
New Secretariat Building,
Nagpur-440001.

PUBLIC SECTOR UNDERTAKINGS

1. Mineral Exploration Corporation Ltd.,
Seminary Hills,
Nagpur-440006.

2. Bharat Aluminium Co. Ltd.,
Punj House,
18, Nehru Place,
New Delhi-110019.

3. Hindustan Copper Ltd.,
Indian Copper Complex,
Ghatsila, District,
Singhbhum-832102.

4. Hindustan Zinc Ltd.,
Z.S. Debari,
Udaipur,
Rajasthan-313024.

5. Bharat Gold Mines Ltd.,
Suvarna Bhavan, Oorgam,
P.O. Kolar Gold Fields,
Pin. 563120.

6. Sikkim Mining Corporation,
Rangpo,
Sikkim.

MINISTRY OF TOURISM & CIVIL AVIATION

DEPARTMENT OF CIVIL AVIATION

1. Technical Centre,
   Research & Development Directorate,
   Safdarjung,
   New Delhi-110003

2. Indian Institute of Tropical
   Meteorology,
   Ramdurg House,
   University Road,
   Pune-411005.

3. Indian Institute of Astrophysics,
   Bangalore-560034.

4. Indian Institute of Geomagnetism,
   Colaba,
   Bombay-400005.

5. India Metreological Department,
   Mausam Bhavan,
   Lodhi Road,
   New Delhi-110003.

MINISTRY OF WORKS & HOUSING

ATTACHED OFFICES

1. National Buildings Organization,
   9, Wing, Nirman Bhavan,
   New Delhi-110001.

SUBORDINATE OFFICES

1. Town & Country Planning
   Organisation,
   'E' Block, Delhi Vikas Bhavan,
   Indraprastha Estate,
   New Delhi-110002.

PUBLIC SECTOR UNDERTAKINGS

1. National Buildings Construction
   Corporation Ltd.,
   Integrated Office Complex,
   Lodhi Road,
   New Delhi-110003.

2. Housing Urban Development
   Corpn.Ltd.,
   18-A, Jamnagar House,
   New Delhi-110001.

3. Hindustan Prefab Ltd.,
   Jangpura,
   New Delhi-110014.

IV STATUTORY BODIES

1. Delhi Development Authority,
   Vikas Minar,
   I.P. Estate,
   New Delhi-110002.

2. Delhi Urban Art Commission,
   2nd Floor, Lok Nayak Bhavan,
   Khan Market,
   New Delhi-110003.

LIST OF UNIVERSITIES

ANDHRA PRADESH

1. Andhra University,
   Waltair,
   Vishakhapatnam.

2. Andhra Pradesh Agricultural
   University,
   Rajendra Nagar,
   Hyderabad-500030.

3. Andhra Pradesh Open University,
   6-3-345, Somajiguda,
   Hyderabad-500004.

4. Hyderabad University,
   Hyderabad-500001.

5. Jawaharlal Nehru Technological
   University,
   Hyderabad-500008.

6. Kakatiya University,
   Hyderabad-506009.

7. Nagarjuna University,
   Guntur(AP)-622516.

8. Osmania University,
   Hyderabad-500007.

9. Sri Krishnadevaraya
   University,
   Anantapur. A.P.

10. Sri Venkateswara
    University,
    Tirupati-517502.

ASSAM

11. Assam Agricultural University,
    Jorhat-785013.

12. Dibrugarh University,
    Dibrugarh-736004.

13. Gauhati University,
    Gauhati-781004.

BIHAR

14. Bhagalpur University,
    Bhagalpur-812007.

15. Bihar University,
    Muzaffarpur.

16. Birsa Agricultural
    University,
    Kanke,
    Ranchi-834006.

17. Kameshwar Singh Darbhanga
    Sanskrit University,
    Darbhanga.

18. Lalit Narayan Mathila
    University,
    Darbhanga.

19. Patna University,
    Patna-800005.

20. Rajendra Agricultural
    University,
    Samastipur-848125.

21. Ranchi University,
    Ranchi.

GUJARAT

22. Bhavnagar University,
    Bhavnagar-364002.

23. Gujarat University,
    Ahmedabad-380009.

24. Gujarat Agricultural
    University,
    Banas Kantha,
    Sardar Krishinagar,
    Dantiwada-385506.

25. Gujarat Ayurveda University,
    Jamnagar.

26. Maharaja Sayajirao
    University of Baroda,
    Baroda-390002.

27. Sardar Patel University,
Vallabh Vidyanagar,
Via-Anand-388120.

28. Saurashtra University,
Rajkot-360005.

29. South Gujarat University,
P.B.No.49,
Surat-395007.

HARYANA

30. Haryana Agricultural
University,
Hissar-125004.

31. Kurukshetra University,
Kurukshetra-132119.

32. Maharishi Dayanand
University,
Rohtak-124001.

HIMACHAL PRADESH

33. Himachal Pradesh
University,
Simla-171005.

34. Himachal Pradesh
Agricultural University,
Palampur-176062.

JAMMU AND KASHMIR

35. Jammu University,
Jammu-180001.

36. Kashmir University,
Srinagar-196006.

37. Sher-e-Kashmir University
of Agricultural Sciences
and Technology,
P.B.No.262,
Srinagar-1900001.

KARNATAKA

38. Bangalore University,
Bangalore-560056.

39. Gulbarga University,
Gulbarga, Karnataka.

40. Karnatak University,
Dharwar-580033.

41. Mangalore University,
Light House Hill,
Mangalore-3.

42. Mysore University,
Mysore-570005.

43. University of Agricultural
Sciences,
Gandhi Krishi Vignana Kendra,
Bangalore-560024.

KERALA

44. Calicut University,
Calicut-673635.

45. Cochin University,
Cochin-682301.

46. Kerala University,
Trivandrum-1.

47. Kerala Agricultural
University,
Main Campus,
Vellanikkara,
Trichur-51.

MADHYA PRADESH

48. Awadesh Pratap Singh
University,
Rewa-486003.

49. Bhopal University,
Bhopal.

50. Devi Ahilya Vishwavidyalaya,
Indore-452001.

51. Jawaharlal Nehru Krishi
Vishwavidyalaya,
Jabalpur-482004.

52. Jiwaji University,
Gwalior-474002.

53. Rani Durgavati Vishwavidyalaya,
Jabalpur-482001.

54. Ravi Shankar University,
Raipur-492002.

55. Dr. Hari Singh Gour
Vishwavidyalaya,
Sagar-470003.

56. Indira Kala Sangeet
Vishwavidyalaya,
Khairagarh. M.P.

57. Vikram University,
Ujjain-456010.

MAHARASHTRA

58. Bombay University,
Bombay-400032.

59. Konkan Krishi University,
Dapoli,
Ratangiri-415712.

60. Mahatma Phule Krishi
Vidyapeeth,
Rahuri Distt.
Ahmednagar.

61. Marathwada University,
Aurangabad-431004.

62. Marathwada Krishi
Vidyapeeth,
Parbhani-2.

63. Nagpur University,
Nagpur.

64. Poona University,
Poona-411007.

65. Punjabrao Krishi
Vidyapeeth,
Akola-444104.

66. Shrimati Nathibai Damodar
Thakersey Women's University,
Bombay-400020.

67. Shivaji University,
Kolhapur-416004.

MANIPUR

68. Manipur University,
Canchipur,
Imphal-795003.

MEGHALAYA

69. North Eastern Hill
University,
P.O. Lower Lachumiere,
Shillong-793001.

ORISSA

70. Berhampur University,
Berhampur-767007.

71. Orissa University of
Agricultural & Technology,
Bhubaneswar-451003.

72. Sambalpur University,
Jyoti Vihar, Burla,
Dt. Sambalpur-768017.

73. Shri Jagannath Sanskrit
Vishwavidyalaya,
Puri.

74. Utkal University,
Vani Vihar,
Bhubaneswar-751004.

PUNJAB

75. Guru Nanak Dev University,
Amritsar.

76. Panjab University,
Chandigarh-160014.

77. Punjab Agricultural
University,
Ludhiana.

78. Punjabi University,
Patiala.

RAJASTHAN

79. Jodhpur University,
Jodhpur.

80. Mohanlal Sukhadia
Vishwavidyalaya,
Pratapnagar,
Udaipur-313001.

81. Rajasthan University,
Jaipur-302004.

TAMIL NADU

82. Anna University,
Guindy,
Madras-600025.

83. Annamalai University,
Annamalainagar-608101.

84. Bharathiar University,
Coimbatore-641041.

85. Bharathidasan University,
Tiruchirapalli.

86. Madras University,
Madras-600005.

87. Madurai Kamaraj University,
Madurai-625021.

88. Tamil University,
Thanjavur.

89. Tamilnadu Agricultural
University,
Coimbatore-641003.

UTTAR PRADESH

90. Agra University,
Agra-208004.

91. Aligarh Muslim University,
Aligarh-202001.

92. Allahabad University,
Allahabad-211002.

93. Avadh University,
Faizabad-224001.

94. Banaras Hindu University,
Varanasi-221005.

95. Bundelkhand University,
Jhansi-284003.

96. Chandra Sekhar Azad
University of Agricultural
& Technology
Kanpur-206002.

97. Garhwal University,
Srinagar(Garhwal).

98. G.B.Pant University of
Agriculture & Technology,
Pantnagar,
Nainital-263145.

99. Gorakhpur University,
Gorakhpur.

100. Kanpur University,
Kanpur.

101. Kashi Vidyapith,
Varanasi-221002.

102. Kumaon University,
Nainital-263001.

103. Lucknow University,
Lucknow-226007.

104. Meerut University,
Meerut.

105. Narendra Deo University of
Agricultural & Technology,
Faizabad-224001.

106. Rohilkhand University,
Bareilly-243001.

107. Roorkee University,
Roorkee-247672.

108. Sampurnanand Sanskrit
Vishwavidyalaya,
Varanasi.

WEST BENGAL

109. Bidhan Chandra Krishi
Vishwavidyalaya,
Kalyani-741246.

110. Burdwan University,
Burdwan-713104.

111. Calcutta University,
Calcutta-700073.

112. Jadavpur University,
Calcutta-700073.

113. Kalyani University,
Kalyani, Dt. Nadia,
W.B.-741235.

114. North Bengal University,
Rajaram Mohanpur,
Darjeeling-734430.

115. Rabindra Bharati,
Calcutta-700050.

116. Vidya Sagar University,
Midnapore(Camp),
88-A, Rash Behari Avenue,
Calcutta-700026.

117. Visva Bharati,
Shantiniketan-731235.

DELHI

118. Delhi University,
Delhi-110007.

119. Jawaharlal Nehru
University,
New Mehrauli Road,
New Delhi-110067.

INSTITUTIONS DEEMED TO BE UNIVERSITIES

ANDHRA PRADESH

1. Central Institute of
English & Foreign Languages,
Hyderabad-500007.

2. Sri Sathya Sai Institute
of Higher Learning,
Prasanthi Nilayam-515134.

BIHAR

3. Indian School of Mines,
Dhanbad-626004.

GUJARAT

4. Gujarat Vidyapith,
Ahmedabad-380014.

KARNATAKA

5. Indian Institute of Science,
Bangalore-560012.

MAHARASHTRA

6. Tata Institute of Social
Sciences,
Deonar,
Bombay-400088.

RAJASTHAN

7. Birla Institute of Technology
and Science,
Pilani-333031.

TAMILNADU

8. Gandhigram Rural Institute,
Gandhigram,
Dt. Madurai-624302.

UTTAR PRADESH

9. Dayalbagh Educational Institute,
Agra-282005.

10. Gurukul Kangri Vishwavidyalaya,
Hardwar,
Uttar Pradesh.

DELHI

11. Indian Agricultural Research
Institute,
Pusa Institute,
New Delhi-110012.

12. Jamia Millia Islamia,
New Delhi-110025.

13. School of Planning and
Architecture,
New Delhi-110002.

INSTITUTIONS OF NATIONAL IMPORTANCE

ANDHRA PRADESH

1. Dakshina Bharat Hindi Prachar Satha,
P.B.No.68,
Hyderabad-500004.

MAHARASHTRA

2. Indian Institute of Technology,
Powai,
Bombay-400076.

TAMIL NADU

3. Indian Institute of Technology,
Madras-600036.

UTTAR PRADESH

4. Indian Institute of Technology,
Agricultural Gardens,
Kanpur-208016.

WEST BENGAL

5. Indian Institute of Technology,
Kharagpur,
Midnapore-721302.

6. Indian Statistical Institute,
203, Barackpore,
Trunk Road,
Calcutta-700035.

CHANDIGARH

7. Postgraduate Institute of Medical Education & Research,
Sector-12,
Chandigarh-160012.

DELHI

8. All India Institute of Medical Sciences,
Ansari Nagar,
New Delhi-110016.

9. Indian Institute of Technology,
Hauz Khas,
New Delhi-110029.

TABLES

TABLE—1

TRENDS IN NATIONAL EXPENDITURE ON RESEARCH, DEVELOPMENT AND RELATED SCIENTIFIC AND TECHNOLOGICAL ACTIVITIES 1948-49 TO 1982-83.

(Rupees crores)

Year	1948-49	1950-51	1955-56	1958-59	1965-66	1970-71	1974-75	1976-77	1977-78	1978-79	1979-80	1980-81	1981-82 (Estimated)	1982-83 (Estimated)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
(A) Expenditure on R&D														
Central Sector	1.10	4.68	12.14	21.78	62.45	112.47	231.14	300.54	343.92	412.49	500.36	545.31	627.10	721.16
State Sector	n.a.	n.a.	n.a.	1.00	3.51	12.58	24.00	25.20	28.50	40.24	46.04	51.95	58.18	65.16
Private Sector	n.a.	n.a.	n.a.	0.15	2.43	14.59	36.46	48.42	58.20	75.87	92.14	103.93	124.72	149.66
Total (A)	1.10	4.68	12.14	22.93	68.39	139.64	291.60	374.16	430.62	528.60	638.54	701.19	810.00	935.98
(B) Expenditure on Related S&T Activities														
Central Sector	n.a.	n.a.	n.a.	5.88	16.67	33.73	27.78	9.95	11.61	19.32	23.07	27.97	32.16	36.98
State Sector	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	4.65	6.85	8.00	10.77	12.72	14.01	15.69	17.57
Total (B)	n.a.	n.a.	n.a.	5.88	16.67	33.73	32.43	16.80	19.61	30.09	35.79	41.98	47.85	54.55
Grand Total (A+B).	1.10	4.68	12.14	28.81	85.06	173.37	324.03	390.96	450.23	558.69	674.33	743.17	857.85	990.53

Source (i) Data for 1948-49 and 1950-51, Science Policy and Organisation of Scientific Research in India Page 99.

(ii) Data up to 1970-71 Report on Science & Technology, 1970-71 brought out by CoST. For subsequent years data compiled by DST.

Note 1. Data for 1948-49 represents only expenditure of CSIR, ICAR, ICMR and DAE.

2. A number of organisations are engaged in scientific and technological activities, such as weather forecasting, geophysical surveys, teaching, consultancy etc. In addition they also undertake research for which in a number of cases, no separate account is maintained. Wherever such details have not been provided, their expenditure on research has been estimated.

3. The number of units in the private sector varies from year to year. Data for 1965-66 relates to 60 companies and that for 1969-70 relates to 109 companies. From 1971-72 onwards, data relates to the companies recognised by the DST under the Import Trade Control Policy, For 1971-72 to 1973-74 it relates to 191 companies for 1974-75 to 1975-76 to 300 companies, for 1976-77 to 1978-79 to 326 Companies and for 1978-79 to 1980-81 to 470 companies.

4. Data for 1981-82 and 1982-83 have been estimated by applying the following rates of growth:
Central Sector—15%, State Sector—12%, Private Sector—20%.

TABLE—2

EXPENDITURE ON S&T IN RELATION TO GNP 1958-59 TO 1980-81

Sl. No.	Particulars	1958-59	1965-66	1970-71	1973-74	1974-75	1976-77	1977-78	1978-79	1979-80	1980-81
1.	GNP at current prices (Rs. crores)	12600	21866	36452	53447	62972	71575	80946	86754	94052	112156@
2.	Expenditure on R&D (Rs. crores)	22.93	68.39	139.64	216.01	291.60	374.16	430.62	528.60	638.54	701.19
3.	Expenditure on R&D as percentage of GNP	0.18	0.31	0.38	0.40	0.46	0.52	0.53	0.61	0.68	0.62
4.	Expenditure on R&D and related S&T activities (Rs. crores)	28.81	85.06	173.37	253.53	324.03	390.96	450.23	558.69	674.33	743.17
5.	Expenditure on R&D and related S&T activities as percentage of GNP	0.23	0.39	0.47	0.47	0.52	0.55	0.56	0.64	0.71	0.66

@ Quick estimate

Source: (i) Data of GNP for 1958-59 to 1977-78 taken from 'R&D Statistics—1978-79'. For Subsequent years data obtained from C.S.O.
(ii) Data on R&D and S&T expenditures compiled by DST.

TABLE—3

EXPENDITURE ON R&D BY SOURCE AND BY PERFORMER FROM 1976-77 TO 1980-81 AT CURRENT AND CONSTANT PRICES WITH 1970-71 AS THE BASE

Sl. No.	Year	Expenditure on R&D by source (Rs. Crores)		Expenditure on R&D by performer (Rs. Crores)	
		at current prices	at constant prices	at current prices	at constant prices
1.	1976-77	379.07	227.40	374.16	224.46
2.	1977-78	436.64	253.20	430.62	249.72
3.	1978-79	542.68	309.27	528.60	301.30
4.	1979-80	649.47	324.71	638.54	319.27
5.	1980-81	715.08	321.75	701.19	315.53

Note:— For working out R&D expenditure at constant prices, GNP price deflators have been used.
Source:— Data compiled by DST.

TABLE—4

R&D EXPENDITURE BY MAJOR SCIENTIFIC AGENCIES UNDER THE CENTRAL GOVERNMENT

Sl. No.	Name	R&D Expenditure (Rs. Lakhs)						
		1958-59	1969-70	1973-74	1976-77	1978-79	1979-80	1980-81
1.	Department of Atomic Energy	775.88	2072.06	2445.63	5831.74	6082.32	6781.46	7623.24
2.	Council of Scientific and Industrial research	509.94	1868.07	2500.77	4125.71	5592.39	5918.99	7281.79
3.	Defence Research and Development Organisation	150.00	1454.39	3428.97	5065.00	6678.61	9662.91	7970.00
4.	Indian Council of Agriculture Research	372.29	1377.08	2408.42	3739.24	5603.56	7739.81	6599.27
5.	Indian Council of Medical Research	50.50	156.46	170.00	423.00	533.54	598.50	842.08
6.	Department of Science and Technology	22.13	73.88	213.67	1121.20	2389.83	2603.56	3537.30
7.	Department of space	—	—	1909.22	3892.45	4553.74	4421.13	5270.85
8.	Department of electronics	—	—	97.53	422.01	511.47	750.25	431.35
	Total	1880.74	7001.94	13174.21	24620.35	31945.46	38476.61	39555.88

Source:— Data compiled by DST.

TABLE—5

R&D EXPENDITURE BY CENTRAL MINISTRIES/DEPARTMENTS FROM 1978-79 TO 1980-81

Sl. No	Name	R&D Expenditure (Rs. Lakhs)		
		1978-79	1979-80	1980-81
1.	Agriculture	149.68	163.51	180.90
2.	Food	102.26	111.02	128.14
3.	Irrigation	335.62	366.47	534.83
4.	Commerce	315.87	374.52	590.07
5.	Chemicals & Fertilizers	569.26	689.58	746.86
6.	Communications	1233.42	1565.19	1752.07
7.	Defence Production	1227.85	1520.42	2428.46
8.	Education	629.53	760.27	1681.65
9.	Energy (Coal)	41.97	47.68	51.44
10.	Energy (Power)	64.05	68.79	55.38
11.	Health & Family Welfare	267.34	318.26	374.36
12.	Home Affairs	6.52	6.47	6.82
13.	Information & Broadcasting	19.59	16.38	28.28
14.	Industry & Civil Supplies (Heavy Industry)	1581.26	2106.08	2296.84
15.	Industry & Civil Supplies (Industrial Development)	276.44	301.75	417.07
16.	Petroleum	694.80	912.06	1066.31
17.	Railways	517.53	555.28	637.19
18.	Shipping & Transport	0.58	0.48	2.60
19.	Steel	221.40	444.26	486.84
20.	Mines	166.32	127.74	316.89
21.	Statistics	—	—	—
22.	Supply & Rehabilitation	28.20	32.43	32.98
23.	Tourism & Civil Aviation	843.20	1042.27	1133.91
24.	Works & Housing	9.69	26.39	23.12
25.	Others	2.52	3.25	2.54
	Total	9304.90	11560.55	14975.55

Source: Data compiled by DST

TABLE—6

R&D AND S&T EXPENDITURE BY THE STATE GOVERNMENT 1978-79 TO 1980-81

(Rs. Lakhs)

Sl. No.	Name of State Government	1978-79	1979-80	1980-81
1.	Andhra Pradesh	346.30	382.81	421.63
2.	Assam	85.91	115.42	91.58
3.	Bihar	312.03	504.52	554.10
4.	Gujarat	480.32	476.41	535.15
5.	Haryana	226.19	330.33	355.71
6.	Himachal Pradesh	130.82	150.44	173.01
7.	Karnataka	311.34	362.34	506.00
8.	Kerala	240.34	228.94	255.37
9.	Madhya Pradesh	191.42	211.96	238.61
10.	Maharashtra	782.31	882.81	931.21
11.	Orissa	369.74	406.58	447.18
12.	Punjab	380.24	463.13	488.87
13.	Rajasthan	174.29	223.46	237.91
14.	Tamil Nadu	374.64	384.11	490.35
15.	Uttar Pradesh	538.74	574.47	665.81
16.	West Bengal	158.14	179.97	205.37
	Total	5102.77	5877.70	6597.86

Source: Data compiled by DST.

TABLE—7

R&D EXPENDITURE BY COOPERATIVE RESEARCH ASSOCIATIONS FROM 1978-79 TO 1980-81

(Rs. Lakhs)

Sl. No.	Name	R&D Expenditure		
		1978-79	1979-80	1980-81
1.	Ahmedabad Textile Industry's Research Association	63.39	71.13	102.21
2.	Silk & Art Silk Mills Research Association	24.16	26.41	91.09
3.	South India Textile Industry's Research Association	37.44	37.71	67.78
4.	Bombay Textile Research Association	46.45	49.63	59.25
5.	Indian Plywood Industry's Research Association	16.93	17.03	21.98
6.	Tea Research Association	158.12	157.60	159.47
7.	Indian Jute Industry's Research Association	82.29	82.26	121.00
8.	Wool Research Association	9.37	10.30*	11.33*
9.	Cement Research Institute	123.10	152.96	180.02
10.	Indian Rubber Manufacturers Research Association	2.15	2.04	4.61
11.	Automotive Research Association of India	20.36	17.66	46.66
12.	Electronics Research and Development Association	14.15	10.57	20.51
	Total	597.91	635.30	885.91

*Estimated

Source: Data compiled by DST.

TABLE—8

INDUSTRIAL R&D EXPENDITURE BY PUBLIC SECTOR-MINISTRY/DEPARTMENT/STATE GOVT. WISE DURING 1980-81

Sl. No.	Name of Ministry/ Department/State Govt.	Name of Public Sector undertaking	R&D Expenditure (Rs. lakhs)	Sales Turn Over (Rs. lakhs)	R&D Expenditure as % age of Sales Turnover
1.	Atomic Energy	Uranium Corporation of India Ltd.	5.64	783.00	0.72
2.	Chemicals & Fertilisers	Fertilizer Planning and Development India Ltd.	304.74	1231.00	24.75
		The Fertilisers and Chemicals Travncore Ltd.	64.45	13434.00	0.47
		Hindustan Insecticides Ltd.	18.75	2040.00	0.92
		Hindustan Organic Chemicals Ltd.	77.60	3267.00	2.37
		Hindustan Antibiotics Ltd.	85.04	2150.00	3.95
		Indian Drugs and Pharmaceuticals Ltd.	112.52	7509.00	1.49
		Madras Fertilizers Ltd.	8.26	13216.00	.06
3.	Communications	Hindustan Teleprinters Ltd.	58.50	700.00	8.35
		Indian Telephone Industries Ltd.	1163.26	14363.00	8.09
4.	Defence Production	Bharat Dynamics Ltd.	7.60	805.00	0.94
		Bharat Earth Movers Ltd.	285.52	14680.00	1.94
		Bharat Electronics Ltd.	893.00	9983.00	8.94
		Garden Reach Shipbuilders and Engineers Ltd.	55.00	4072.00	1.35
		Hindustan Aeronautics Ltd.	1183.07	16625.00	7.11
		Mazagon Docks Ltd	0.10	8550.00	—
		Praga Tools Ltd.	4.17	675.00	0.61
5.	Electronics	Computer Maintenance Corporation Ltd.	117.73	800.00	14.71
		Electronics Trade & Technology Development Corpn. Ltd.	13.92	1815.00	0.76
6.	Energy (Coal)	Bharat Coking Coal Ltd.	38.09	18466.00	0.20
		Neyveli Lignite Corporation Ltd.	9.61	10714.00	0.08
7.	Health & Family Welfare	Hindustan Latex Ltd.	3.96	161.00	2.45
8.	Heavy Industry	Bharat Pumps and Compressors Ltd.	33.62	1826.00	1.84
		Bharat Heavy Electricals (Corporate)	1864.00	77600.00	2.40
		Hindustan Machine Tools	82.00	18971.00	0.43
		Heavy Engineering Corporation Ltd.	47.57	7476.00	0.63
		Mining and Allied Machinery Corpn. Ltd.	5.28	2725.00	0.19
		Richardson & Cruddas Ltd.	26.52	1000.00	2.65
		Scooters India Ltd.	0.14	2778.00	—
		Tungabhadra Steel Products Ltd.	1.00	645.00	0.15
		Triveni Structural Ltd.	3.75	—	—
		Bharat Heavy Electricals Trichy	232.96	25465.00	0.91
9.	Industrial Development	Hindustan Photo Films Manufacturing Company Ltd.	55.00	6500.00	0.84
		Hindustan Paper Corporation Ltd.	5.47	1337.00	0.40
		Hindustan Salts Ltd.	1.77	354.00	0.50
		Instrumentation Ltd.	85.56	4200.00	2.03
		National Instruments Ltd.	7.56	351.00	2.15
10.	Petroleum	Engineers India Ltd.	28.00	2429.00	1.15
		Indian Oil Corporation Ltd.	314.16	571094.00	0.05
		Indian Petrochemicals Ltd.	98.93	28073.00	0.35
		Lubrizol India Ltd.	0.40	2637.00	0.01
		Oil and Natural Gas Commission	438.76	45999.00	0.95
11.	Science and Technology	Central Electronics Ltd.	160.00	107.62	148.68
12.	Steel	Bokaro Steel Plant	35.98	35136.00	0.10
		Steel Authority of India Ltd, (R&D)	500.00	218798.00	0.23
		Visvesvaraya Iron and Steel Ltd.	3.40	7200.00	0.04
13.	Mines	Bharat Aluminium Co. Ltd.	60.00	4928.00	1.21
		Bharat Gold Mines Ltd.	45.72	2427.00	1.88
		Hindustan Zinc Ltd.	84.84	5300.00	1.60
		Hindustan Copper Ltd.	55.56	3058.00	1.81
		Mineral Exploration Ltd.	19.58	78.00	25.10
14.	Gujarat	Gujarat State Fertilizers Company Ltd.	7.53	11599.00	0.06
15.	Karnataka	The Mysore Electrical Industries Ltd.	9.37	176.00	5.32
		NGEF Ltd.	36.09	5000.00	0.72
16.	Kerala	Travancore Titanium Products Ltd.	2.16	1282.00	0.16
17.	Punjab	Punjab Biomedical Equipments Ltd.	7.75	—	—
		Punjab Digital Industrial Systems Ltd.	3.00	6.00	50.00
		Punjab Tractors Ltd.	37.00	4800.00	0.77
		Punjab Wireless Ltd.	12.00	50.00	24.00
18.	Uttar Pradesh	UP Electronics Corporation Ltd.	13.40	74.00	18.10
19.	West Bengal	The Electro-Medical & Allied Industries Ltd.	5.50	19.00	28.94
		West Bengal Electronic Industry Development Corporation Ltd.	8.32	100.00	8.32

TABLE—9

INDUSTRIAL R&D EXPENDITURE BY INDUSTRY GROUPS FROM 1978-79 TO 1980-81

Sl. No.	Industry groups	Public sector				Private sector				Total			
		No. of units	R&D expenditure (Rs. lakhs)			No. of units	R&D expenditure (Rs. lakhs)			No. of units	R&D expenditure (Rs. lakhs)		
			1978-79	1979-80	1980-81		1978-79	1979-80	1980-81		1978-79	1979-80	1980-81
1.	Metallurgical Industries	8	272.01	547.77	746.42	29	337.42	522.76	553.78	37	609.43	1070.53	1300.20
2.	Fuels	3	539.29	608.06	791.01	5	98.92	117.90	121.07	8	638.21	725.96	912.08
3.	Boilers & Steam Generating Plants	—	—	—	—	—	—	—	—	—	—	—	—
4.	Prime Movers (Other than Electrical Generators)	—	—	—	—	4	80.83	110.07	175.50	4	80.88	110.07	175.50
5.	Electrical Equipment	9	255.89	375.22	367.33	97	954.35	1212.86	1405.23	106	1210.24	1588.08	1772.56
6.	Telecommunications	3	802.97	1086.42	1233.76	8	153.98	223.00	211.56	11	956.95	1309.42	1445.32
7.	Transportation	1	0.92	4.01	0.14	16	640.82	984.40	1136.95	17	641.74	988.41	1137.09
8.	Industrial Machinery	6	1557.07	2061.93	2209.18	33	553.11	555.92	724.82	39	2110.18	2617.85	2934.00
9.	Machine Tools	1	34.77	49.41	82.00	4	137.54	144.74	144.15	5	172.31	194.15	226.15
10.	Agricultural Machinery	1	12.01	63.57	37.00	4	236.85	230.31	284.75	5	248.86	293.88	321.75
11.	Earth Moving Machinery	—	—	—	—	1	13.95	32.02	30.00	1	13.95	32.02	30.00
12.	Misc. Mech. Engineering Industries	2	6.40	19.53	28.68	3	9.74	19.06	32.29	5	16.14	38.59	60.97
13.	Commercial, Office, Household Equipment	—	—	—	—	6	25.08	30.89	45.22	6	25.08	30.89	45.22
14.	Medical & Surgical Appliances	1	5.50	5.80	7.75	2	11.10	11.89	10.86	3	16.60	17.69	18.61
15.	Industrial Instruments	2	77.03	80.06	93.12	18	71.74	76.79	111.01	20	148.77	156.85	204.13
16.	Scientific Instruments	—	—	—	—	8	8.55	12.31	15.31	8	8.55	12.31	15.31
17.	Math. Surveying & Drawing Instruments	—	—	—	—	—	—	—	—	—	—	—	—
18.	Fertilizers	4	355.72	322.70	385.24	3	34.56	46.22	49.72	7	390.28	368.92	434.96
19.	Chemicals (other than Fertilizers)	6	85.09	267.39	235.28	99	1530.22	1677.45	1791.49	105	1615.31	1944.84	2026.77
20.	Photographic Raw Film & Paper	1	33.90	38.02	55.00	—	—	—	—	1	33.90	38.02	55.00
21.	Dyestuffs	—	—	—	—	11	213.71	291.03	373.21	11	213.71	291.03	373.21
22.	Drugs & Pharmaceuticals	2	204.11	266.39	197.56	35	880.88	1123.44	1367.39	37	1084.99	1389.83	1564.95
23.	Textiles (Dyed, Printed, Processed)	—	—	—	—	21	317.04	441.87	420.16	21	317.04	441.87	420.16
24.	Paper & Pulp (Incl. Paper Products)	1	3.97	3.54	5.47	12	161.28	99.50	144.34	13	165.25	103.04	149.81
25.	Sugar	—	—	—	—	5	9.05	11.63	37.70	5	9.05	11.63	37.70
26.	Fermentation Industries	—	—	—	—	—	—	—	—	—	—	—	—
27.	Food Processing Industries	—	—	—	—	6	50.27	111.54	160.45	6	50.27	111.54	160.45
28.	Vegetable Oils & Vanaspati	—	—	—	—	3	8.21	11.59	19.50	3	8.21	11.59	19.50
29.	Soaps, Cosmetics, Toilet Preparations	—	—	—	—	7	261.35	279.97	298.98	7	261.35	279.97	298.98
30.	Rubber Goods	1	3.42	3.76	3.96	4	146.32	167.59	221.17	5	149.74	171.35	225.13
31.	Leather, Leather Goods & Pickers	—	—	—	—	—	—	—	—	—	—	—	—
32.	Glue & Gelatin	—	—	—	—	—	—	—	—	—	—	—	—
33.	Glass	—	—	—	—	3	17.56	19.04	23.42	3	17.56	19.04	23.42
34.	Ceramics	—	—	—	—	9	148.89	131.15	135.66	9	148.89	131.15	135.66
35.	Cement & Gypsum Products	—	—	—	—	2	363.80	414.09	207.37	2	363.80	414.09	207.37
36.	Timber Products	—	—	—	—	2	16.60	11.09	10.40	2	16.60	11.09	10.40
37.	Defence Industries	7	1227.85	1520.42	2429.46	—	—	—	—	7	1227.85	1520.42	2429.46
38.	Miscellaneous Industries	3	40.68	17.17	74.91	10	93.75	92.45	129.97	13	134.43	109.62	204.88
	Total	62	5518.60	7341.17	8983.27	470	7587.52	9214.57	10393.43	532	13106.12	16555.74	19376.70

Source: Data compiled by DST.

TABLE—10

INDUSTRIAL R&D EXPENDITURE, EXPENDITURE ON ADVERTISING, NEW PLANT AND EQUIPMENT VERSUS SALES TURNOVER FROM 1978-79 TO 1980-81

Sl No	Year	R&D Expenditure (Rs. lakhs)		Advertising Expenditure (Rs. lakhs)		Expenditure on New Plant and Equipment (Rs. lakhs)		Sales Turnover (Rs. lakhs)		R&D Expenditure as % of Sales Turn Over		Advertising as % of Sales Turn Over		New Plant & Equipment Expenditure as % of Sales Turn Over	
		Public sector	Private sector	Public sector	Private sector	Public sector	Private sector	Public sector	Private sector	Public sector	Private sector	Public sector	Private sector	Public sector	Private sector
1	1978-79	5519	7588	9284	3206	32433	25041	745811	949514	0.74	0.79	1.24	0.33	4.34	2.63
2	1979-80	7341	9215	2349	3351	29281	27234	847591	1075964	0.78	0.85	0.27	0.31	3.45	2.53
3	1980-81	8983	10393	5442	3600	35192	33499	1249676	1241910	0.72	0.83	0.44	0.28	2.82	2.69

Source: Data compiled by DST.

TABLE—11

R&D & S&T EXPENDITURE BY TYPE OF WORK BY CENTRAL AND STATE GOVTS. FROM 1978-79 TO 1980-81

(Rs. Crores)

Year	Central Government					State Government					Total				
	Basic research	Applied research	Experimental development	Other activities	Total	Basic research	Applied research	Experimental development	Other activities	Total	Basic research	Applied research	Experimental development	Other activities	Total
1978-79	49.25	133.01	134.80	19.32	336.38	4.80	26.62	7.59	10.77	49.78	54.05	159.63	142.39	30.09	386.16
1979-80	59.07	160.36	164.07	23.07	406.57	5.51	30.27	8.94	12.72	57.44	64.58	190.63	173.01	35.79	464.01
1980-81	72.76	170.38	166.27	27.98	437.39	6.20	34.19	10.13	14.02	64.54	78.96	204.57	176.40	42.00	501.93

Source: Data compiled by DST.

TABLE—12

R&D EXPENDITURE BY OBJECTIVES FROM 1978-79 TO 1980-81

(Rs. lakhs)

Sl. No.	Objectives	Central Government			State Government		
		1978-79	1979-80	1980-81	1978-79	1979-80	1980-81
1.	Exploration and Assesment of Earth, Seas, Atmosphere	2626.00	2644.66	3007.92	3.36	4.02	4.48
2.	Space	4553.74	4421.13	5270.85	2.51	3.38	3.30
3.	Development of Agriculture, Forestry and Fishing	7649.80	10006.66	9594.02	3618.06	4167.43	4605.31
4.	Promotiom of Industrial Development	6663.90	8034.97	9370.47	69.49	81.87	101.02
5.	Production, Conservation and Distribution of Energy	5617.28	6494.31	7615.90	81.14	92.17	126.57
6.	Development of transport and Communication	2997.82	3545.33	3965.64	44.13	34.94	34.91
7.	Development of Education Services	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
8.	Development of Health Services	1426.39	1664.84	1953.92	199.09	211.02	308.71
9.	Social Development and other Socio-Economic Services	493.46	569.80	671.55	7.01	9.61	10.96
10.	Protection of the Environment	43.36	38.40	76.80	—	—	—
11.	General Advancement of Knowledge	1611.57	1900.36	3263.64	—	—	—
12.	Other Aims	165.01	179.12	235.36	—	—	—
13.	Defence	7402.03	10537.58	9505.36	—	—	—
	Total	41250.36	50037.16	54531.43	4024.79	4604.4	5195.26

TABLE—12 *(Cont.)*

R&D EXPENDITURE BY OBJECTIVES FROM 1978-79 TO 1980-81

(Rs. lakhs)

Sl. No.	Objectives	Private sector			Total		
		1978-79	1979-80	1980-81	1978-79	1979-80	1980-81
1.	Exploration and Assesment of Earth, Seas, Atmosphere	4.10	4.55	5.50	2633.46	1653.23	3017.90
2.	Space				4556.25	4424.51	5274.15
3.	Development of Agriculture, Forestry and Fishing	395.41	464.31	628.76	11663.27	14638.40	14828.09
4.	Promotiom of Industrial Development	4638.83	5243.49	5688.18	11372.22	13360.33	15159.67
5.	Production, Conservation and Distribution of Energy	617.19	843.11	1032.97	6315.61	7429.59	8775.44
6.	Development of transport and Communication	1026.15	1504.01	1617.48	4068.10	5084.28	5618.03
7.	Development of Education Services	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
8.	Development of Health Services	902.80	1150.08	1412.36	2528.28	3025.94	3674.99
9.	Social Development and other Socio-Economic Services	—	—	—	500.47	579.41	682.51
10.	Protection of the Environment	—	—	—	43.36	38.40	76.80
11.	General Advancement of Knowledge	3.03	5.00	8.01	1614.60	1905.36	3271.65
12.	Other Aims	.01	.02	.17	165.02	179.14	235.53
13.	Defence	—	—	—	7402.03	10537.58	9505.36
	Total	7587.52	9214 57	10393.43	52862.67	63855.37	70120.12

TABLE—13

SECTORAL DISTRIBUTION OF R&D EXPENDITURE 1980-81

Sl. No.	Sector	Expenditure on R&D (Rs. lakhs)			
		Total	Central sector	State sector	Private sector
1.	Natural Resources	2244.14	2214.70	13.54	15.90
2.	Marine Resources	808.15	717.00	91.15	—
3.	Meteorology	938.06	906.49	31.45	0.12
4.	Fuel & Power	2486.50	1168.56	135.94	1182.00
5.	Steel, Mines & Metallurgy	2547.38	1987.46	2.16	557.76
6.	Special Materials	299.65	155.21	—	144.44
7.	Machine Tools	543.12	398.97	—	144.15
8.	Heavy Engineering	3536.11	2516.84	1.02	1018.25
9.	Chemical Industries	6818.36	2994.31	30.38	3793.67
10.	Consumer Industries	2109.11	1213.08	8.40	887.63
11.	Khadi & Village Industries & Small Scale Sector.	14.72	14.72	—	—
12.	Recycling of Wastes	1.52	1.52	—	—
13.	Housing Urbanisation & Construction Technology	908.69	673.58	21.24	213.87
14.	Family Welfare & Health	1777.74	1391.24	285.86	100.64
15.	Transport	1855.20	682.02	3.23	1169.95
16.	Education	3506.70	3506.70	—	—
17.	Information	162.83	158.83	—	4.00
18.	Environmental Quality	323.36	323.36	—	—
19.	Agriculture	11378.71	6600.83	4468.40	309.48
20.	Atomic Energy	6899.88	6899.88	—	—
21.	Space	5270.85	5270.85	—	—
22.	Electronics, Communications etc.	5401.29	4620.51	28.40	752.38
23.	Defence	9505.36	9505.36	—	—
24.	Others	782.69	609.41	74.09	99.19
	Total	70120.12	54531.43	5195.26	10393.43

Source. Data compiled by DST.

TABLE—14

R&D EXPENDITURE BY FIELD OF SCIENCE

	Central Government			State Government		
	1978-79	1979-80	1980-81	1978-79	1979-80	1980-81
1. Natural Sciences	5017.37	5575.92	7863.11	6.44	7.79	8.09
2. Engineering & Technology	26950.79	32640.39	35385.91	272.76	345.09	378.95
3. Medical Sciences	1208.39	1398.49	1731.63	201.60	214.40	312.01
4. Agricultural Sciences	6062.21	8262.38	7336.40	3538.74	4029.98	4488.21
5. Social Sciences	1270.44	1260.11	1248.74	5.25	7.18	8.00
6. Others	741.16	899.87	965.64	—	—	
Total	41250.36	50037.16	54531.43	4024.79	4604.44	5195.26

Source: Data compiled by DST.

TABLE—14 (*Cont.*)

R&D EXPENDITURE BY FIELD OF SCIENCE

	Private sector			Total		
	1978-79	1979-80	1980-81	1978-79	1979-80	1980-81
1. Natural Sciences	1875.11	2196.24	2282.32	6898.92	7787.95	10123.52
2. Engineering & Technology	4914.52	5957.91	6775.53	32138.07	38943.39	42540.39
3. Medical Sciences	735.48	974.55	1207.12	2145.47	2587.44	3250.76
4. Agricultural Sciences	62.41	83.87	158.46	9663.36	12376.23	11983.07
5. Social Sciences	—	—	—	1275.69	1267.29	1256.74
6. Others	—	—	—	741.16	899.87	965.64
Total	7587.52	9214.57	10393.43	52862.67	63855.37	70120.12

Source: Data compiled by DST

TABLE—15

STOCK OF SCIENTIFIC AND TECHNICAL PERSONNEL 1950-1985

Category of Personnel	Stock at the end of the year (000)						
	1950	1955	1960	1965	1970	1980 Estimated	1985 Estimated
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(a) Engineering and Technology							
(i) Degree	21.6	37.5	62.2	106.7	185.4	221.4	266.3
(ii) Diploma	31.5	46.8	75.0	138.9	244.4	329.4	429.9
(b) Science							
(i) Post Graduates	16.0	28.0	47.7	85.7	139.2	217.5	273.0
(ii) Graduates	60.0	102.9	165.6	261.5	420.0	750.3	956.5
(c) Agriculture							
(i) Post Graduates	1.0	2.0	3.7	7.7	13.5	96.5	114.1
(ii) Graduates	6.9	11.5	20.2	39.4	47.2	—	—
(d) Medicine							
(i) Degree	18.0	29.0	41.6	60.6	97.8	167.6	198.7
(ii) Licentiate	33.0	35.0	34.0	31.0	27.0	N.A.	N.A.
Total	188.0	292.7	450.0	731.5	1174.5	1782.70	2238.5

Source: Columns (2) to (6) Division of Scientific & Technical personnel CSIR. Cols. (7) & (8) Sixth Five Year Plan, 1980-85, Planning Commission.

Note: During the years, 1980 & 1985, the numbers or Bscs who were also BEds were estimated to be 1.66 lakhs and 2.28 lakhs. Similar figures for the earlier years are not available.

TABLE—16

ESTIMATED STOCK, NUMBER OF ECONOMICALLY ACTIVE PERSONS, UNEMPLOYMENT AND EMPLOYMENT OF SCIENTIFIC & TECHNICAL PERSONS IN 1980 AND 1985

(Figures in 000's)

Sl. No.	Category	1980 (Beginning)					1985 (Beginning)			
		Stock	No. of economically active	unemployment	Unemployment percentage to economically active	Inter se percentage of unemployment rates	Stock	No. of economically active	Unemployment	Employment
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1.	Engineering Degree Holders	254.5	221.4	15.7	7.09	7.8	306.1	266.3	18.9	247.4
2.	Engineering Diploma Holders	378.6	329.4	65.5	19.88	21.9	494.1	429.9	85.5	344.4
3.	Medical Graduates	178.5	155.3	10.1	6.50	7.2	211.9	184.3	12.0	172.3
4.	Dental Surgeons	11.6	10.1	0.2	1.98	2.2	13.4	11.6	0.2	11.4
5.	Nurses (B.Sc.)	2.2	2.2	—	—	—	2.8	2.8	—	2.8
6.	Agricultural Graduates	98.8	77.1	8.8	11.41	12.6	115.9	90.4	10.3	80.1
7.	Veterinary Graduates	22.3	19.4	0.7	3.60	3.9	27.3	23.7	0.9	22.8
8.	Science Graduates	961.9	750.3	154.3	20.57	22.6	1226.3	956.5	196.8	759.7
9.	Science Post Graduates	278.9	217.5	10.6	4.87	5.4	350.0	273.0	13.3	259.7
10.	B.Sc./B.Ed.	213.2	166.3	24.8	14.90	16.4	284.2	227.7	35.7	191.9
	Total	2400.5	1949.0	290.7	14.90	—	3032.0	2466.1	373.6	2092.5

Source: Annexure 13.9, Page 220 of Sixth Five Year Plan, 1980-85 Planning Commission.

TABLE--17

FULL TIME EQUIVALENT OF MANPOWER EMPLOYED IN R&D ESTABLISHMENTS

Sl. No.	Name of Establishment	Personnel engaged primarily in R&D activities	Personnel engaged on auxilliary/ scientific/ technical activities	Personnel employed in administrative & other non-technical supporting activities.	Total
(1)	(2)	(3)	(4)	(5)	(6)
1.	Department of Atomic Energy	4200	7200	5002	16402
2.	Council of Scientific & Industrial Research	6269	8417	5620	20306
3.	Defence Research and Development Organisation	6904	7120	7340	21364
4.	Indian Council of Agriculture Research	4815	4856	8213	17884
5.	Space	3637	3522	3467	10626
6.	Indian Council of Medical Research	457	832	867	2156
7.	Other Central Government agencies	17737	16348	15569	49654
8.	State Governments	9247	4741	8502	22490
9.	Private Sector	11609	5106	6499	23214
	Total	64875	58142	61079	184096

Source: Data compiled by DST.

TABLE

EDUCATIONAL QUALIFICATIONS OF

Sl. no.	Name	Ph.Ds.						Post Graduates						Graduates					
		Nat. Sc.	Agr.	Engg.	Med.	Soc. Sc.	Total	Nat. Sc.	Agr.	Engg.	Med.	Soc. Sc.	Total	Nat. Sc.	Agr.	Engg.	Med.	Soc. Sc.	Total
1.	D.A.E.	638	6	—	—	—	644	1194	7	100	42	—	1343	684	5	890	42	—	1621
2.	C.S.I.R.	1187	63	209	8	2	1469	1626	104	509	17	44	2300	1074	107	457	20	17	1675
3.	D.R.D.O.	144	—	26	—	11	181	2182	11	326	7	39	2565	1320	9	967	5	—	2301
4.	I.C.A.R.	211	747	23	—	9	990	506	1309	81	—	44	1940	53	125	69	1	11	259
5.	I.C.M.R.	98	—	—	19	9	126	125	4	1	67	30	227	43	1	—	26	3	73
6.	Space	160	3	61	—	1	225	355	11	467	—	28	861	190	—	788	—	15	993
7.	Other Institutions under the Central Govt.	935	36	194	33	38	1236	1756	131	1180	194	294	3555	1887	168	2961	74	94	5184
8.	State Govts.	141	799	23	5	23	991	466	3194	143	51	136	3990	427	1351	406	40	36	2260
9.	Private Sector	483	44	231	26	7	791	1214	54	1035	60	21	2384	1807	76	2522	62	33	4500
	Total	3997	1698	767	91	100	6653	9424	4825	3842	438	636	19165	7485	1842	9060	270	209	18866

Source: Data compiled by DST.

TABLE—19

WOMEN PERSONNEL IN DIFFERENT SECTORS AND IN DIFFERENT CATEGORIES IN R&D ESTABLISHMENTS 1980-81

Sector	Engaged in R&D	Engaged in Auxiliary work	Engaged in Administrative work	Total
Central	2356	2224	4057	8637
State	295	157	535	987
Private	341	148	261	750
Total	2992	2529	4853	10374

Source: Data compiled by DST.

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PERSONNEL ENGAGED IN R&D ·

Diploma holders						Others						Total					
Nat. Sc.	Agr.	Engg.	Med.	Soc. Sc.	Total	Nat. Sc	Agr.	Engg.	Med.	Soc. Sc.	Total	Nat. Sc	Agr.	Engg.	Med.	Soc. Sc	Total
—	5	488	2	—	495	97	—	—	—	—	97	2613	23	1478	86	—	4200
1	4	265	2	1	273	204	32	196	1	43	476	4092	310	1636	48	107	6193
—	—	1723	—	—	1723	106	2	20	—	—	128	3752	22	3062	12	50	6898
1	16	181	2	—	200	183	503	24	—	3	713	954	2700	378	3	67	4102
—	—	6	4	—	10	—	—	—	20	—	20	266	5	7	136	42	456
—	—	648	—	8	656	38	—	852	—	12	902	743	14	2816	—	64	3637
16	78	2323	4	8	2429	606	99	2013	52	34	2804	5200	512	8671	357	468	15208
—	86	177	—	—	263	330	1000	163	—	14	1507	1364	6430	912	96	209	9011
83	17	1746	2	2	1850	381	37	1578	22	48	2066	3968	228	7112	172	111	11591
101	206	7557	16	19	7899	1945	1673	4846	95	154	8713	22952	10244	26072	910	1118	61296

TABLE—20

WOMAN SCIENTISTS & TECHNOLOGISTS ENGAGED IN R&D BY EDUCATIONAL QUALIFICATIONS AND FIELD OF SCIENCE 1980-81

Educational Qualifications	Disciplines					
	Natural Science	Agricultural Science	Engineering	Medical Science	Social Science	Total
Ph.D.	312	36	5	10	15	378
Post-graduates	795	109	82	131	129	1246
Graduates	521	26	179	85	35	846
Diploma holders	10	—	172	3	1	186
Other Qualifications	49	67	103	12	9	240
Total	1687	238	541	241	189	2896

Source: Data compiled by DST.

TABLE—21

DETAILS OF PROCESSES REFFERED TO NRDC FOR DEVELOPMENT AND COMMERCIAL EXPLOITATION 1980-81

Sl. No.	Name of Research Institute	No. of Inventions reported Upto 31.3.80	During 1980-81	Total	Less Inventions dropped/with drawn	No. of effective inventions	No. of inventions licensed	No. of inventions released free
(1)	(2)	(3)	(4)	(5)	(6)	(8)	(8)	(9)
1.	CSIR	1558	28	1586	228	1358	818	111
2.	ICAR	39	1	40	6	34	14	4
3.	ICMR	1	—	1	—	1	1	—
4.	A.I.I.M.S.	9	1	10	—	10	4	—
5.	D.A.E.	7	—	7	—	7	2	—
6.	D.R.D.O.	8	—	8	—	8	6	—
7.	Ministry of Defence	163	6	169	27	142	57	1
8.	Ministry of Railways	45	—	45	10	35	18	1
9.	Deptt. of Agriculture	22	1	23	10	13	4	4
10.	Deptt. of Food	15	—	15	6	9	5	—
11.	Ministry of Information & Broadcasting	11	1	12	5	7	5	—
12.	Ministry of Transport	1	—	1	1	—	—	—
13.	Ministry of Communication	5	—	5	—	5	5	—
14.	Ministry of Works and Housing	2	—	2	—	2	2	—
15.	Ministry of Health & Family Welfare	1	—	1	1	—	—	—
16.	Deptt. of Heavy Industry	5	2	7	—	7	3	—
17.	Deptt. of Irrigation	11	—	11	—	11	3	—
18.	Deptt. of Power	3	—	3	—	3	2	—
19.	Ministry of Petroleum	4	—	4	—	4	4	—
20.	Ministry of Energy	1	—	1	—	1	—	—
21.	Ministry of Chemicals & Fertilizers	7	—	7	—	7	—	—
22.	Instts. of Higher Education							
(i)	IISc Bangalore	41	—	41	29	12	4	—
(ii)	IIT, Madras	1	—	1	—	1	1	—
(iii)	IIT, Delhi	11	—	11	—	11	4	—
(iv)	IIT, Kanpur	1	—	1	—	1	1	—
(v)	Indian School of Mines	3	—	3	3	—	—	—
(vi)	Deptt. of Chem. Tech. Bombay	3	—	3	3	—	—	—
(vii)	Jadavpur University, Calcutta	2	—	2	2	—	—	—
(viii)	Instt. of Radio Physics & Elect. Calcutta	1	—	1	1	—	—	—
23.	Other							
(a)	Shri Ram Instt. for Industrial Research	33	—	33	12	21	13	—
(b)	Oil Tech. Res. Instt. Anantpur	2	—	2	—	2	2	—
(c)	Mysore Engg. Res. Stn.	1	—	1	—	1	1	—
(d)	Technical Teachers Training Institure	4	—	4	—	4	4	—
(e)	Private Individuals	56	—	56	20	36	4	—
(f)	Foreign Countries	9	—	9	9	—	—	—
(g)	Madras Port Trust	1	—	1	—	1	1	—
(h)	Ramakrishna Mission	3	—	3	—	3	—	—
(i)	National Small Ind. Corporation	1	—	1	—	1	—	—
(j)	Instt. of Design of Elect. Measuring Instruments, Bombay.	3	—	3	—	3	—	—
(k)	Maharashtra Engg. Res. Instt. Nasik	1	—	1	—	1	—	—
(l)	Others	10	1	11	—	11	2	—
	Total	2106	41	2147	373	1774	990	121

Source: Annual Report of NRDC, 1980-81.

TABLE - 22

ROYALTY AND PREMIA BY NRDC

Year	Gross Royalty (Rs. in lakhs)	Gross Premia (Rs. in lakhs)	Total (Rs. in lakhs)
1976-77	51.54	15.97	67.51
1977-78	44.98	15.42	60.40
1978-79	46.77	18.93	65.70
1979-80	56.46	16.33	72.79
1980-81	72.75	10.52	83.27

Source: Annual Report of NRDC, 1981-82.

TABLE—23

NUMBER OF APPLICATIONS FOR PATENTS FROM PERSONS IN INDIA AND ABROAD DURING THE PERIOD 1968 TO 1972 AND DURING 1972-73 TO 1980-81

	1968	1969	1970	1971	1972	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Indians	1,110	1,120	1,116	1,231	1,180	1,143	976	1,148	1,129	1,342	1,097	1,124	1,055	1,159
Foreigners resident in India.	107	168	162	185	142	136	174	66	34	23	37	13	37	19
Foreigners residing abroad	4,141	4,158	3,864	2,929	2,373	2,360	2,341	2,192	1,833	1,739	1,736	1,795	1,888	1,776
Total	5,358	5,446	5,142	4,345	3,695	3,639	3,491	3,406	2,996	3,104	2,870	2,932	2,980	2,954

Source: The Controller General of Patents, Designs & Trade Marks.

TABLE—24

PATENT APPLICATIONS FILED DURING THE PERIOD 1968 TO 1972 AND DURING 1972-73 TO 1980-81

Year	No. of applications made	No. of applications brought forward from preceding year	Total No. of applications to be examined	No. of applications examined	No. of complete specifications found in order for acceptance on 1st examination	No. of applications deemed to have been abandoned due to non-filling of complete specifications	Total No. of complete specifications notified as accepted during the year	No. of applications deemed to have been abandoned due to non-acceptance of complete specifications	No. of applications carried forward to next year	No. of patents sealed		No. of patents in Force	
										Indian	Foreign	Indian	Foreign
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1968	5,358	3,714	9,072	4,686	193	234	3,988	562	4,152	426	3,704	3,547	37,816
1969	5,446	4,152	9,598	4,914	225	550	3,537	464	4,335	645	4,308	2,231	25,483
1970	5,142	4,254	9,376	4,614	289	738	3,867	514	4,024	596	2,936	2,568	25,753
1971	4,345	4,024	8,369	4,714	302	882	3,576	857	2,773	629	3,294	3,063	27,663
1972	3,695	2,773	6,468	3,085	95	111	1,973	172	3,272	265	1,245	3,673	28,650
1972-73	3,639	2,728	6,367	2,834	81	122	1,820	172	3,411	278	1,064	3,718	28,718
1973-74	3,491	3,411	6,902	1,520	Nil	327	2,545	394	5,055	358	1,058	3,948	28,270
1974-75	3,406	5,055	8,461	2,908	6	152	2,505	398	5,401	737	3,207	3,039	24,758
1975-76	2,996	5,401	8,397	3,898	4	623	2,487	5,842	3,876	426	1,894	2,991	23,453
1976-77	3,104	3,876	6,980	3,612	6	295	2,840	533	3,067	928	1,964	2,746	19,780
1977-78	2,870	3,067	5,937	2,369	10	378	2,507	577	3,122	657	1,857	3,065	19,795
1978-79	2,932	3,190	6,122	1,266	10	283	2,070	498	4,573	281	1,000	2,469	13,966
1979-80	2,980	4,573	7,553	1,498	15	304	1,210	429	5,751	516	1,657	2,786	14,474
1980-81	2,954	5,751	8,705	2,301	5	325	1,007	372	6,079	349	670	2,757	14,448

Source: The Controller General of Patents, Designs & Trade Marks.

TABLE - 25

APPLICATIONS FOR PATENTS FILED IN THE YEAR 1978-79, 1979-80, 1980-81 FROM DIFFERENT STATES

Sl. No.	State/Union Territory	No. of applications filed		
		1978-79	1979-80	1980-81
(1)	(2)	(3)	(4)	(5)
1	Maharashtra	267	278	296
2	Delhi	287	283	333
3.	West Bengal	143	108	110
4.	Tamil Nadu	103	98	112
5.	Gujarat	53	55	72
6.	Karnataka	58	43	38
7.	Uttar Pradesh	30	52	37
8.	Andhra Pradesh	34	39	34
9.	Bihar	33	29	36
10	Kerala	40	25	35
11.	Madhya Pradesh	11	14	13
12.	Rajasthan	22	11	10
13.	Punjab	13	13	17
14.	Haryana	8	3	15
15	Others	35	41	20
	Total	1137	1092	1178

Source: The Controller General of Patents, Designs & Trade Marks.

TABLE—26

APPLICATIONS FOR PATENTS FILED IN THE YEAR 1978-79, 79-80, 80-81 BY FOREIGN COUNTRIES

Sl. No	Country	Number of applications for patents filed		
		1978-79	1979-80	1980-81
(1)		(2)	(3)	(4)
1.	U.S.A.	605	650	570
2.	F.R.G.	300	282	274
3.	U.K.	178	244	210
4.	France	120	121	133
5.	Switzerland	105	89	90
6	Italy	51	58	77
7.	Japan	80	93	96
8.	U.S.S.R.	44	61	57
9.	Netherland	42	57	50
10.	Hungary	34	14	25
11.	Others	236	219	194
	Total	1795	1888	1776

Source: The Controller General of Patents, Designs & Trade Marks.

TABLE—27

INTERNATIONAL COMPARISON OF R&D EFFORTS

Sl. No.	Name of Country	Year	Population 'lakhs'	Per capita GNP at current prices in US $	R&D expenditure as percentage of GNP	Per capita R&D expenditure in US $
1.	Argentina	1978	257	1910*	1.0*@	9.62
2.	Australia	1976	135	6100	1.0	70.57
3.	Canada	1977	232	7537	1.1	94.69
4.	Czechoslovakia	1978	151	4720	4.2*@	193.59
5.	Finland	1977	47	5763	1.1	68.07
6.	France	1977	531	6411	1.8	127.22
7.	Germany (FRG)	1977	619	7456	2.3	180.61
8.	Ghana	1976	103	580	0.9*@	2.09
9.	Greece	1976	92	2590	0.2	5.19
10.	India	1980-81	6780	204	0.7	1.35
11.	Iran	1974	321	1060	0.3	1.71
12.	Italy	1978	571	4118	0.8	28.41
13.	Japan	1978	1141	7153	1.9	118.85
14.	Kenya	1975	134	220	0.8	1.20
15.	Korea (Rep)	1978	364	1187	1.0	8.65
16.	Netherland	1976	138	6200	2.1	136.48
17.	Peru	1976	161	800	0.3	2.63
18.	Poland	1978	350	3660	1.9	38.78
19.	Sweden	1977	83	8841	2.0	184.23
20.	Switzerland	1976	64	8880	2.3*	212.03
21.	U.K.	1975	560	3690	2.0	84.87
22.	U.S.A.	1978	2185	8612	2.5*@	216.90
23.	U.S.S.R.	1978	2600	3700*	4.6*@	111.81
24.	Yugoslavia	1978	219	2390*	1.1	23.56

*@ Expenditure as percentage of Net material product.
* Indicates figure for 1976.
Source: Statisties an Science & Technology, UNESCO.

TABLE—28

SCIENTISTS AND ENGINEERS BY COUNTRY

Sl. No.	Name of the Country	Year	Population '000'	Scientists Engineers & Technicians in R&D/1000 of Population	Stock of Scientists Engineers & Technicians/ 1000 Population
1.	Argentina	1978	25,700**	0.74	105.95*
2.	Australia	1976	13,500	2.52	46.64
3.	Bulgaria	1978	8,804**	5.03	87.16**
4.	Canada	1978	23,500	1.74**	28.78+
5.	Cuba	1977	9,500	1.15**	6.27**
6.	Czechoslovakia	1978	15,100	7.26	22.51*
7.	Finland	1977	4,737	3.00	229.35
8.	France	1977	53,100	4.18	8.85+@*
9.	Germany (FRG)	1977	61,900	3.51+@*	19.58
10.	Ghana	1976	10,300	0.95	2.55@
11.	Greece	1976	9,200	0.47	22.01+
12.	India	1980-81	6,78,000	0.10	2.63
13.	Iran	1974	35,000	0.19++	6.77
14.	Italy	1978	57,100	1.16	78.71+
15.	Japan	1978	1,14,100	4.28	273.68+@*
16.	Kenya	1975	13,400	0.04	0.82
17.	Korea (Republic)	1978	36,400**	0.64	21.96**
18.	Netherland	1976	13,800	3.92	56.24+
19.	Peru	1976	15,600+@*	0.27+@*	9.42+@*
20.	Poland	1978	35,000	4.39	142.92+@
21.	Sweden	1977	8,300	4.39	N.A.
22.	Switzerland	1976	6,400	4.19	39.67+@*
23.	U.K.	1975	56,000	2.77	N.A.
24.	U.S.A.	1978	218,500	2.99	15.85*
25.	U.S.S.R.	1978	260.000	5.02	97.24**
26.	Yugoslavia	1978	21,900	1.54	136.30*

Note: 1. @ indicate figures for 1970
2. + indicate figures for 1971
3. ++ indicate figures for 1972
4. +@ indicate figures for 1974
5. +@* indicate figures for 1975
6. * indicate figures for 1976
7. ** indicate figures for 1977

Source: Statisties on Science & Technology, USESCO.

TABLE – 29

EXPENDITURE ON SCIENCE & TECHNOLOGY, 1974-80

(Rs. crores)

Sl	Agency Department/Ministry	1974-75			1975-76			1976-77			1977-78			1978-79			1979-80		
		Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
A.	S&T Agencies																		
1.	Atomic Energy (R&D)	18.24	23.64	41.88	27.18	28.49	55.67	31.02	30.00	61.02	28.91	32.21	61.12	30.74	34.60	65.34	28.38	41.68	70.06
2.	Space	17.26	13.47	30.73	22.48	14.67	37.15	23.80	15.42	39.22	22.75	15.64	38.39	29.09	16.71	45.80	23.38	25.11	48.49
3.	DST	03.83	15.10	18.93	08.15	18.63	26.78	13.20	21.02	34.22	15.94	24.45	40.39	17.95	25.94	43.89	16.18	32.04	48.22
4.	CSIR	09.76	22.60	32.36	11.90	25.21	37.11	14.02	27.44	41.46	18.49	29.60	48.09	19.14	30.89	50.03	21.79	32.49	54.28
5.	NTH	00.02	00.58	00.60	00.14	00.60	00.74	00.14	00.62	00.76	00.20	00.63	00.83	00.16	00.62	00.78	00.19	00.61	00.80
	Total 'A'	49.11	75.39	124.50	69.85	87.60	157.45	82.18	94.50	176.68	86.29	102.53	188.82	97.08	108.76	205.84	89.92	131.93	221.85
B.	S&T Component under Ministries/ Departments																		
6.	Heavy Industry	00.39	00.50	00.89	01.73	00.50	02.23	02.95	00.50	03.45	07.65	05.06	12.71	07.08	08.91	15.99	09.72	16.12	25.84
7.	Industrial Development	00.06	00.22	00.28	00.84	0.12	0.96	1.72	0.43	2.15	2.75	0.56	3.31	2.68	1.15	3.83	1.49	2.65	4.14
8.	Commerce*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
9.	Steel	00.22	—	00.22	0.61	—	0.61	0.71	—	0.71	0.97	—	0.97	1.97	—	1.97	4.67	—	4.67
10.	Mines	—	—	—	0.02	—	0.02	0.54	—	0.54	0.48	—	0.48	1.84	0.06	1.90	1.15	0.32	1.47
11.	Power	00.40	00.29	0.69	0.47	0.38	0.85	0.84	0.40	1.24	0.70	0.64	1.34	0.87	0.73	1.60	1.22	0.96	2.18
12.	Coal	—	—	—	—	—	—	1.25	—	1.25	1.25	—	1.25	1.35	1.62	2.97	2.11	2.37	4.48
13.	Petroleum	01.24	00.58	1.82	1.80	0.75	2.55	1.64	1.71	3.35	1.86	1.72	3.58	2.17	2.82	4.99	4.60	3.40	8.00
14.	Chemicals and Fertilisers	—	—	—	0.07	—	0.07	0.19	0.25	0.44	0.51	0.26	0.77	0.97	0.10	1.07	3.16	0.27	3.43
15.	Electronics	00.74	02.95	3.69	1.29	1.09	2.38	3.27	0.96	4.23	3.80	1.37	5.17	5.31	0.81	6.12	8.19	0.77	8.96
16.	Communications	01.78	01.33	3.11	3.09	2.31	5.40	4.17	3.35	7.52	4.93	4.37	9.30	5.02	5.07	10.09	5.60	4.72	10.32
17.	Information & Broadcasting	—	00.18	0.18	—	0.19	0.19	0.06	0.24	0.30	0.06	0.25	0.31	0.06	0.25	0.31	0.22	0.30	0.52
18	Shipping & Transport	—	—	—	—	—	—	0.30	—	0.30	0.64	—	0.64	1.04	0.72	1.76	1.78	0.77	2.55
19	TCA IMD & Instts.	02.05	7.44	9.49	2.98	8.32	11.30	2.23	9.53	11.76	5.76	9.81	15.57	6.10	9.74	15.84	9.17	11.55	20.72
20	Works & Housing	—	—	—	—	—	—	—	—	—	—	—	—	0.21	0.67	0.88	0.20	0.71	0.91
21.	Labour	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.10	—	0.10
22.	Education	2.40	—	2.40	5.36	—	5.36	5.62	—	5.62	5.87	—	5.87	5.17	0.83	6.00	4.70	1.97	6.67
23.	Health ICMR	2.55	—	2.55	3.20	—	3.20	4.26	—	4.26	4.49	—	4.49	1.49	3.81	5.30	2.10	4.05	6.15

24.	Social Welfare	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
25.	Rural Re-construction**	—	—	—	—	—	—	—	—	—	—	—	—	0.73	—	0.73	0.88	—	0.88
26.	Agri-ICAR	14.60	14.15	28.75	22.85	16.20	39.05	29.07	17.30	46.37	39.20	19.98	59.18	47.65	20.26	67.91	53.07	32.85	85.92
	Agri. F-RI	0.21	—	0.21	0.29	—	0.29	0.37	—	0.37	0.61	—	0.61	0.90	—	0.90	1.25	—	1.25
27.	Food	0.19	0.32	0.51	0.59	0.37	0.96	0.45	0.43	0.88	0.49	0.38	0.87	0.47	0.45	0.92	0.91	0.49	1.40
28.	Irrigation	0.27	—	0.27	0.30	—	0.30	0.22	—	0.22	0.38	—	0.38	0.72	—	0.72	1.00	—	1.00
29.	Railways (RDSO)	—	3.78	3.78	—	4.60	4.60	—	4.41	4.41	—	4.47	4.47	—	5.75	5.75	—	6.36	6.36
	Total 'B'	27.10	31.74	58.84	45.49	34.83	80.32	59.86	39.51	99.37	82.40	48.87	131.27	93.80	63.75	157.55	117.52	90.40	207.92
	Grand Total (A+B)	76.21	107.13	183.34	115.34	122.43	237.77	142.04	134.01	276.05	168.69	151.40	320.09	190.88	172.51	363.39	207.44	222.33	429.77

*For Department of Textiles, included under Department of Industrial Development upto 1979-80.

**Upto 1977-78, included under Department of Industrial Development.

For 1979-80, data in respect of Part 'A' relates to Actuals and for Part 'B' it relates to revised estimate.

Source: Sixth Five Year Plan document, 1980-85, Planning Commission.

TABLE—30

SIXTH PLAN OUTLAYS SCIENCE & TECHNOLOGY

(Rs. crores)

Sl. No.	Agency/Deptt./Ministry	1980-85 (Plan Outlay)	1980-85 (Estimated Non-Plan Outlay)*
(1)	(2)	(3)	(4)
A.	S & T Sector-Agencies		
1.	Atomic Energy (R&D)	248.98	284.59
2.	Space (S&T)	245.80	146.92
3.	DST	134.87	189.55
4.	Environment	40.00	13.12
5.	CSIR	170.00	218.24
6.	NTH (Supply)	8.50	3.56
	Sub-Total 'A'	848.15	855.98
B.	Other Sectors-S&T Component under Ministries/Deptts.		
7.	Heavy Industry	57.51	100.00
8.	Industrial Dev.		
	(i) Large & Medium Industries	8.41	10.00**
	(ii) Small Scale Industries	9.29	
9.	Commerce		
	(i) Textiles Research Associations	6.50	8.40
	(ii) Other Programmes	25.00	
10.	Steel	41.70	
11.	Mines	16.16	
12.	Power	53.10	5.00
13.	Coal	25.00	15.00
14.	Petroleum		
	(i) Petroleum	39.08	30.00
	(ii) Petro-Chemicals	5.58	
15.	Chemicals & Fertilizers	26.03	3.50
16.	Electronics	32.34	3.00
17.	Communications	62.15	33.00
18.	Information & Broadcasting	2.50	2.00
19.	Shipping & Transport	12.75	5.00
20.	TCA		
	(i) IMD & Institutes	45.00	73.00
	(ii) R&D Dte., C.A.	1.50	0.80
21.	Works & Ho[illegible]g-CBRI	2.00	3.80
22.	Labour	1.06	
23.	Education	112.00	30.00
24.	Health-ICMR	40.00	26.00
25.	Social Welfare	2.00	
26.	Rural Reconstruction	10.05	
27.	Agriculture		
	(i) ICAR	340.00	190.00
	(ii) FRI	12.00	
28.	Food	8.10	3.30
29.	Irrigation	20.45	14.00
30.	D.S.T.	54.00@	
31.	Railways (RDSO)	—	36.00
	Sub-Total 'B'	1071.26	591.80
	Grand Total (A+B)	1919.41	1447.78

*Tentative Estimates.
**Both for Large & Medium and Small Scale Industries.
@Rs. 50 crores under Energy Sector and Rs. 4 crores under Housing & Urban Development Sector.
Source: Sixth Five Year Plan, 1980-85, Planning Commission.

TABLE—31

Assistance given by U.G.C. for development of Science & Technology

Years	Total grant (Rs. lakhs)		
	Science	Engg. & Technology	Total
1976-77	844.53	390.13	1234.66
1977-78	734.77	299.55	1034.32
1978-79	917.61	477.26	1394.87
1979-80	710.52	264.16	974.68
1980-81	680.32	284.65	964.97

TABLE—32

Assistance for major research projects in 1980 by UGC.

Sl.No.	Subject	Number of projects	Amount approved (Rs. Lakhs)
1.	Physics	31	37.22
2.	Chemistry	70	37.34
3.	Bio-Science	55	41.49
4.	Geology	14	9.97
5.	Geography	7	3.22
6.	Mathematics & Statistics	5	3.05
7.	Engineering	7	18.40
	Total	189	150.69

TABLE—33

Consultancy projects, sponsored research projects and papers published by Indian Institutes of Technology during the year 1977-78

Name	Consultancy projects	Sponsored research projects	Papers published
IIT, Delhi	92	100	508
IIT, Kanpur	103	102	1000
IIT, Madras	197	108	717
IIT, Bombay	272	45	453
IIT, Kharagpur	80	100	466
Total	744	455	3144

TABLE—34

Allocation of resources / time to various activities by the IITs

Name of IIT	Training	Research training	Sponsored research	Consultancy
IIT, Delhi	40%	31%	25%	4%
IIT, Kanpur	36%	38%	23%	3%
IIT, Madras	40.5%	36.6%	17.3%	5.6%
IIT, Bombay	41%	38%	16%	5%
IIT, Kharagpur	44%	36%	17.8%	2.2%

TABLE—35

Estimated outlay for research and consultancy projects for IITs in 1982-83.

Name of IIT	Budget for 1982-83 (Rs. lakhs)	Estimated outlay for research, consultancy (Rs. lakhs)
IIT, Delhi	634.21	380.53
IIT, Kanpur	684.60	438.14
IIT, Madras	623.27	370.84
IIT, Bombay	686.86	405.25
IIT, Khargpur	652.46	365.38
Total	3281.40	1960.14

TABLE—36

Output of Engineers, scientists, and technologists from IITs till January, 1979

Degree	Delhi	Kanpur	Madras	Bombay	Kharagpur	Total
1. B.Tech	2679	2632	4547	4107	6639	20604
2. M.Tech	1215	1437	1694	2050	3106	9502
3. Ph.D (Engg.)	174	217	242	222	397	1252
4. Ph.D (Sc.)	244	320	187	162	343	1256
5. Ph.D (Humanities)	—	—	—	—	7	7
6. B.Sc.	—	—	—	—	562	562
7. M.Sc.	310	387	482	482	714	2375
8. D.I.I.T (Engg.)	210	—	186	355	373	1124
9. D.I.I.T (Sc.)	—	—	—	—	298	298
10. D.I.I.T (Humanities)	—	—	—	—	43	43
11. M.S.	27	—	138	—	—	165
12. D.Sc (Engg.)	—	—	—	—	2	2
13. D.Sc (Sc.)	—	—	—	—	7	7
Total	4859	4993	7476	7378	12491	37197

TABLE—37

Doctorate Degrees Awarded

Faculty	1973–74	1974–75	1975–76	1976–77	1977–78	1978–79	1979–80
Science	1327	1515	1516	1671	1906	2044	2261
Engineering/Technology	95	163	136	152	168	134	176
Medicine	46	50	42	49	51	48	56
Agriculture	276	281	289	334	329	364	422
Veterinary Science	56	60	44	66	81	58	58
Total	1800	2069	2027	2272	2535	2648	2973

Note – The above data does not include degrees awarded by IITs

TABLE—38

Number of patents sealed for selected years during 1972-73 to 1980-81

Year	No. of patents sealed		
	Indians	Foreigners	Total
1972-73	278	1064	1342
1974-75	737	3207	3944
1976-77	928	1964	2892
1978-79	281	1000	1281
1980-81	349	670	1019

TABLE—39

Number of applications for patents filed in the year 1972-73 to 1980-81 for selected years

Year	No. of applications for patents filed		
	Indians	Foreigners	Total
1972-73	1143	2496	3639
1974-75	1148	2258	3406
1976-77	1342	1762	3104
1978-79	1124	1808	2932
1980-81	1159	1795	2954

TABLE—40

Applications for patents filed in the year 1978-79, 1979-80 and 1980-81 by foreign countries

Sl. No.	Country	No. of applications for patents filed		
		1978-79	1979-80	1980-81
1.	U.S.A.	605	650	570
2.	F.R.G.	300	282	274
3.	U.K.	178	244	210
4.	France	120	121	133
5.	Switzerland	105	89	90
6.	Italy	51	58	77
7.	Japan	80	93	96
8.	USSR	44	61	57
9.	Netherland	42	57	50
10.	Hungary	34	14	25
11.	Others	236	219	194
		1795	1888	1776

TABLE—41

Expenditure on R&D in the Developed and Developing countries

Name	No.	Developing countries expdr. (billion US $)	No.	Developed countries (expdt. billion US $)	No.	Total (Expdt. billion US$)
Africa	9	0.058	—	—	9	0.058
America (north)	9	0.233	2	48.812	11	49.045
America (south)	5	1.496	—	—	5	1.496
Asia	12	1.751	2	13.782	14	15.533
Ocenia	7	0.035	2	1.016	9	1.051
Europe	—	—	21	48.314	21	48.314
USSR	—	—	2	25.914	2	25.914
Total	42	3.573	29	137.838	71	141.411

TABLE—42

Funds devoted to defence research by selected countries

SL.No.	Name of the Country	Year	Total Govt. expdt. on R&D (million US dollars)	% devoted for def ence Research
1.	Canada	1977	0.94	6.7
2.	USA	1976	23.93	49.6
3.	Denmark	1976	0.23	0.8
4.	France	1977	4.06	30.6
5.	FRG	1977	5.48	12.7
6.	Italy	1976	0.71	4.5
7.	Switzerland	1975	0.25	4.9
8.	UK	1975	3.07	48.4
9.	Australia	1973	0.56	12.4
10.	India	1980-81	735.13	13.4

TABLE—43

R&D expenditure as % of GNP in selected countries

Greece	(1976)	0.2	Argentina	(1978)	1.0	Sweden	(1977)	2.0
Iran	(1974)	0.3	Australia	(1976)	1.0	UK	(1975)	2.0
Peru	(1976)	0.3	Korea			Netherland	(1976)	2.1
India	(1980-81)	0.6	Republic	(1978)	1.0			
Kenya	(1975)	0.8	Yugoslavia	(1978)	1.1	Switzer	(1976)	2.3
Italy	(1978)	0.8	Canada	(1977)	1.1	land		
Ghana	(1976)	0.9	Finland	(1977)	1.1	FRG	(1977)	2.3
			France	(1977)	1.8	USA	(1978)	2.5
			Poland	(1978)	1.9	Czechoslavakia	(1978)	4.2
			Japan	(1978)	1.9	USSR	(1978)	4.6

TABLE–44

Per capita GNP and R&D expenditure in selected countries

	Per capita R&D expenditure (US $)						
Per capita GNP US $	0 – 20	20 – 40	40 – 80	80 – 120	120 – 160	160 – 200	200 – 220
2	3	4	5	6	7	8	8
0 – 1000	Ghana Kenya						
1000 – 2000	Argentina Iran Korea (Republic)						
2000 – 3000	Greece	Yugoslavia					
3000 – 4000		Poland	UK USSR				
4000 – 5000	Italy					Czechoslavakia	
5000 – 6000			Finland				
6000 – 7000					France Netherland		
7000 – 8000				Canada		FRG	
8000 – 9000				Japan		Sweden	Switzerland USA

TABLE–45

Scientists. Engineers & Technicians in R&D per thousand of population

Kenya	(1975)	0.04	Cuba	(1977)	1.15	Australia	(1976)	2.52
Iran	(1974)	0.19	Italy	(1978)	1.16	UK	(1975)	2.77
Peru	(1976)	0.27	Yugoslovia	(1978)	1.54	USA	(1978)	2.99
Greece	(1976)	0.47	Canada	(1978)	1.74			
Korea Republic	(1978)							
Argentina	(1978)	0.74	Finland	(1977)	3.00	France	(1977)	4.18
Ghana	(1976)	0.95	Federal Republic of Germany	(1977)	3.57	Switzerland	(1976)	4.19
			Netherland	(1976)	3.92	Japan	(1978)	4.28
						Poland	(1978)	4.39
						Sweden	(1977)	4.39
						USSR	(1978)	5.02
						Czechoslovakia	(1978)	7.26